MINUTES OF EVIDENCE.

Great London Drainage Bill.

(1853.)

Ordered, by The House of Commons, *to be Printed,*
17 *June* 1853.

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TAKEN BEFORE THE

SELECT COMMITTEE

ON THE

GREAT LONDON DRAINAGE BILL.

(1853.)

Ordered, by The House of Commons, *to be Printed,*
17 *June* 1853.

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MINUTES OF EVIDENCE.

Lunæ, 6° *die Junii*, 1853.

LORD SEYMOUR IN THE CHAIR.

Agents for the Promoters :—Messrs. *Deans & Rogers.*
Counsel :—Mr. *Calvert*, Mr. *Hope Scott*, Mr. *Hodges.*

Petitioners against the Bill :

1. The Commissioners of Sewers of the City of London.
   Agent :—Mr. *Edward Tyrrell.*
   Counsel :—Mr. *Gurney*, Mr. *Clerk.*
2. *J. F. Hargrave.*
   Agents :—Messrs. *Dorington & Co.*
   Counsel :—Mr. *Webster.*
3. The Eastern Counties Railway.
   Agents :—Messrs. *Pritt & Co.*
4. The Metropolitan Commissioners of Sewers.
   Agents :—Messrs. *Dyson & Co.*
5. The Company of Proprietors of the Regent's Canal.
   Agents :—Messrs. *Lyon, Barnes & Ellis.*
6. The Trustees of Commercial Roads.
   Agents :—Messrs. *Dyson & Co.*

Mr. *Calvert* was heard to open the case in support of the Bill.

Mr. *Hodges* requested permission to examine Mr. Brassey in the first instance, although rather out of order, in consequence of its being necessary for him to leave England.

Mr. *Thomas Brassey*; Examined by Mr. *Hodges.*

Mr. *T. Brassey.*

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1. ARE you a very considerable contractor for public works of all descriptions?—I am.

2. Have you considered this plan of draining London by means of these intercepting tunnel sewers on each side of the river?—I have.

3. How long has your attention been directed to the subject?—I do not exactly know; but a few months; four or five months since it was first brought to my notice.

4. By the *Committee.*] Never before the last four or five months was it brought to your notice?—No.

5. By Mr. *Hodges.*] Are you of opinion that the mode proposed of carrying off the sewage of the Metropolis is a thing that is practicable, and the best that can be adopted?—I think there is no doubt about its practicability, and in my opinion it is the best that can be adopted.

6. Have you examined the plan prepared by the present company of making one intercepting sewer on each side of the river?—Yes, I have.

7. Have

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7. Have you been in communication with several gentlemen on the subject in the course of the inquiry that you have made upon the matter?—I have seen the engineer and gentlemen who have been promoting the undertaking.

8. And have you considered it is a plan deserving of encouragement and inquiry?—It is so, in my opinion.

9. Among other persons, have you been in communication with Sir Charles Fox on the subject?—Yes, I have.

10. Are you acquainted with the size of the proposed sewer on each side of the river?—Yes, I am.

11. Have you a memorandum of the size; take the north end first?—It is a 10-feet sewer from the Lower Creek, at Barking, to the principal sewer at Fleet Bourn, or Fleet Ditch; it is a 10-feet sewer to there, and I understand an eight-feet sewer from thence to Westminster.

12. Then on the south side?—The south side, I do not know what the size of the sewer is; I have not gone into that question.

13. Have you caused estimates to be prepared at your office?—Yes; that has been my principal consideration of the question.

14. By the *Committee.*] Your estimate is on an eight-foot sewer?—I have so much of eight-feet, and so much of 10-feet.

15. By Mr. *Hodges.*] The estimates have been prepared at your office by persons employed by you?—The estimates have been prepared by one of my principal agents, who has given a great deal of consideration to the question, and gone into great details with the engineer.

16. Is that Mr. Ogilvie?—Yes. I have not personally gone into the calculations myself.

17. Have you seen the estimate prepared by Mr. Ogilvie?—I have a certain bill of quantities furnished to me, which have been taken out by my agent, Mr. Ogilvie; to that bill of quantities certain prices have been applied by him, in conference with myself. The prices I can speak to with confidence; the quantities, I have no doubt whatever, Mr. Ogilvie will be able to satisfy the Committee upon; personally I have not gone into them.

18. Are you prepared to carry out a contract upon that scale of prices, for the sum stated on that paper?—I should be prepared, if required to do so.

19. What is the total amount?—The total of this is, 658,376 *l.* on the north side, and 349,877 *l.* for the south side. You ask me if I should be prepared to enter into a contract on these figures. That is rather a strong proposition to make without looking with great care into them; but I have no doubt whatever that I should be able, and would be enabled to do it, if there was a contingency of 50,000 *l.* added to it. I do not think in matters of this kind, although I believe the price to be perfectly liberal, and such as the work would be let for to-morrow, if it were advertised, perhaps something under it. If you ask me whether I would undertake it personally for that sum, I say I must take some time to consider; at all events not without a further margin of 50,000 *l.*

20. It will approximate to 50,000 *l.*?—I am quite satisfied of that.

21. The works on the north side; would that include the tunnel from one point to the other?—Yes.

22. In your judgment, will there be any engineering difficulty in the way of making that tunnel?—I do not see any whatever; it is a question of money.

23. You have said Mr. Ogilvie has gone very minutely into the calculations; we shall have Mr. Ogilvie examined another day; would you be prepared to adopt any estimate that Mr. Ogilvie may present?—It has been my usual practice to adopt Mr. Ogilvie's estimates, having examined them myself, for many years past. Mr. Ogilvie has executed for me works, I am almost afraid to say how much, but certainly for a couple of millions sterling; I think I have never found his result different from what he anticipated.

24. Does the 50,000 *l.* contingencies include both sides of the river?—I think it would, on this amount of estimate.

Cross-examined by Mr. *Gurney.*

25. Have you the bill of quantities that you spoke of?—Yes.

26. I do not quite know what this includes; you do not know yourself probably?—It includes the completion of the works.

27. You say you have not gone into the question of quantities, but only prices affixed to these quantities?—That is all.

28. Do

28. Do you know whether this takes in the works at the end?—I believe it does.

29. Engines necessary for pumping, for instance?—Yes, it does; it includes all the work that is necessary for depositing the sewage and the reservoir that is made for its receipt at the end.

30. By the *Committee.*] And pumping up water?—And pumping up water, including engine power.

31. By Mr. *Gurney.*] And for the construction of the reservoirs?—Yes, the construction of a reservoir; I think there is only one.

32. One on each side?—Yes, one on both sides of the river. The reservoir is not a very expensive matter; that is a simple bank, or a pond in point of fact. This is only an abstract of the details. The details are long (*producing the same.*)

33. Mr. Ogilvie will give it us still much more fully?—As much as you please.

34. Have you examined the ground at all, so as to ascertain what ground you will be passing through?—The borings were represented to me on sections; I cannot examine it further than the detail and borings go.

35. Have you anything you have assumed to be correct, the account of the borings?—I assume the information that was given me was correct.

36. Upon what information is it you have formed this opinion: does that appear in any paper that has been handed in to us?—That I do not know, I am sure, whether it could or not; whether there is any document that can be handed in, I am not prepared to say.

37. You say the account of the borings appeared on some section that was submitted to you?—Yes, there was a section given to me.

38. Can they be submitted to us?—I have no doubt of it, but it is with the engineer.

39. You have not the paper yourself?—I have no paper myself, except the paper I have handed to you.

40. You know nothing respecting it when you speak of the practicability, except an account of the borings, which were given to you by the engineer?—No; but I know sufficient of it to enable me to say with confidence that that estimate is such as, with the addition of 50,000 *l.*, would justify me in taking the risk.

41. We will ascertain a little more of this if you please; you said you would not do it without some consideration, or at any rate, without a contingency of 50,000 *l.*?—Yes, that is what I think.

42. Does it include the expense they will be at for constructing works in taking houses that we hear of?—I do not know that any houses are necessary.

43. How would you propose to construct the works for this sum?—All by means of a tunnel from one end to the other, under-ground passage.

44. What shafts do you have down in the tunnel?—We have provision for shafts, not in the centre, of taking side-shafts; where we have not got a shaft in the street, we must go sideways.

45. You would take a house?—It has all been gone carefully into, and the expense of sites, where we can get them, and an estimate of it.

46. Have you gone into it, to see whether that would be sufficient?—I have not.

47. Will you point out where that item is?—Here is an item here of 8,000 *l.*, sites for shafts, which I believe applies to it where they cannot obtain it in particular roads.

48. May I assume you have proceeded on the assumption that no work will be required except what appears on that paper?—Yes: I presume that this paper fully provides for all that can be wanted from one end of the sewer to the other.

49. You have not looked into it to ascertain whether the quantities are sufficient?—No, I have not; I know nothing about the quantities.

Mr. *Hodges* stated he would supply a copy of the paper.

Cross-examined by Mr. *Henderson.*

50. This paper is prepared by a gentleman in whom you have confidence?—Yes.

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51. And are you of opinion its accuracy is founded on your opinion of his accuracy?—Yes, entirely so.

52. Your evidence may be understood to be this, applying your knowledge to it; the prices that are charged in proportion to the work to be done?—Fair and reasonable prices.

53. But as to the works themselves that are actually to be done, you have taken that from other parties?—Yes.

54. Does that estimate include the expense of steam-engines?—It does.

55. Have you any knowledge of that subject; are you an engineer?—No; but I know full well the price here is sufficient on them.

56. Does it state the number of horse-power?—Yes; the price. The steam-power for the north side is 1,250 horses, and the price 87,500*l.* for the engines themselves; 20,000*l.* for additional water, pumps, and so on.

57. So far as the prices are concerned, you would accept the estimates?—Yes.

58. You speak to contingencies; there are engineering difficulties, from the nature of the ground?—Yes; there are contingencies that do happen in tunnels.

59. The ground proving to be faulty?—Yes. As I said before, these prices are fair and liberal; if I were asked to take the work myself, the risk of it, I should want something for taking that position, and this sum I estimate at 50,000*l.*

60. You verify the prices, and no more?—Yes, exactly so.

61. Do you know whether the estimate includes the expense of the junction of the sewers intercepted, with the expense of forming the junction and tunnel?—It does; I can give that, if you like.

62. Will you refer to that item; that is the expense of connexion between the existing sewers and the proposed tunnels?—£. 15,000.

63. By the *Committee.*] How many sewers are there running into this?—I do not know the number.

64. By Mr. *Henderson.*] Has this estimate been made recently?—It think it is, perhaps, three months since this estimate was made.

65. Do you know of any estimate made by Mr. Wickstead some years ago?—No, I do not; I personally knew nothing of the question until this last six months.

66. You have taken the statement made out by this gentleman, and applied your knowledge to it, as the case appears on this paper?—Yes.

Re-examined by Mr. *Hodges.*

67. Have you not had great experience in tunnelling?—Yes, I have.

68. Have you not conducted works of a very extensive description?—Yes.

69. You are well acquainted with the practical difficulties that may be supposed to be met with in a case of this kind?—I have done more tunnelling than any other person living.

70. I understood you to say that, with the addition of 50,000*l.* for a margin, you would undertake it, taking all risk of engineering difficulties, and every risk of that kind?—Yes; if it were put to me, I would.

71. By Mr. *Henderson.*] The 50,000*l.* includes both sides?—Yes.

72. By Mr. *Hodges.*] In your judgment, would there be any engineering difficulties, such as to prevent the work from being completed?—I do not see any. Of course there will be water in it; and there is a provision made for pumping water to some extent.

73. It provides for water that may come in?—There is a provision for pumping water on the north side, of 13,365*l.*, which, in my mind, is sufficient.

74. Mr. Ogilvie is a gentleman you have every confidence in?—Yes.

Examined by the *Committee.*

75. You say you have had great experience in making tunnels of this kind?—No; but of a much more difficult kind through some material; railway tunnels I am alluding to particularly.

76. Is not this tunnel below the level of the river?—Yes; but it is in clay, generally.

77. That you have ascertained from borings?—Yes.

78. As to Mr. Ogilvie, on whose information you rely, is it from his engineering knowledge that you rely, or from his calculation as to labour?—I rely upon

it

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it from my own judgment and his too; we are quite agreed on what is the value of the work to be performed; the quantities, I have said before, have been ascertained by Mr. Ogilvie, I believe, in concert with the company's engineer; but they are given to me, and I accept them as correct. I know nothing more of them; I am assuming that the quantities are correct.

79. As to the size of the sewers?—That is my opinion as to the size of the sewers;—and as to their capacity?

80. Yes?—I believe them to be quite abundant, and perhaps too much; but I have no doubt you will get information much better than mine on that subject. I do not pretend to go into any questions; I speak more particularly and confidently as to the value of the work to be executed. As to anything beyond that, my opinion is not worth so much.

81. What is to be the depth of this tunnel at its commencement?—There is a section somewhere; I believe, in all cases, it is 20 feet below the existing sewers.

82. By Mr. *Henderson.*] And much more in some?—Yes, that is the least, as I understand.

83. By the *Committee.*] The depth at which it is to be constructed is an important item in the expense?—No, not very much; it is more a question of shaft; I would rather execute it if it were 50 feet deeper; I should consider the risk less if we were 50 feet lower than it is. The deeper we are, the safer it is; if there is any risk, it is coming too near the surface, and not in going down too low.

84. That would only increase the expense of pumping?—That is all; merely in lift of earth.

85. You said the borings showed your tunnel would be in clay?—Chiefly.

86. What other formation?—Gravel; some little gravel.

87. Where do you find gravel?—I do not quite recollect whereabouts it was on the section; I merely took it out in length, so much of clay, and so much partial gravel.

88. What is the whole distance of the north side?—I believe it is 17,820 yards.

89. Do you consider four feet in a mile a sluggish fall for a matter of this description?—I should think not; I should think it would draw very well at that inclination; I give the best opinion I can.

90. You do not speak so much as an engineer as a contractor?—No.

91. I do not understand you to say that you feel yourself under any obligation to accept this, assuming this Bill were passed, and the parties came to you with a view of entering into a contract with you, and would offer to give you 50,000 *l.* in addition for contingencies; you would not feel yourself under any obligation to accept that, but you merely give it as your evidence, according to your present impression, you should be ready to contract upon those terms?—Oh, yes; I am under no obligation whatever, nor are the parties under any obligation to me; they are free, and they will not give me that if they can do, and I believe they could, better with somebody else. There are persons connected with London that can do this work quite as well as I can do the work; quite as well as I can, and perhaps better.

Mr. *John J. Mitchell*; Examined by Mr. *Hodges.*

Mr. *J. J. Mitchell.*

92. I BELIEVE you are a civil engineer?—I am.

93. Are you the engineer to this proposed company?—I am.

94. Have you had some experience as an engineer?—Yes; I have had considerable.

95. I believe you were brought up with your father?—I was.

96. Had he a Government appointment?—At Sheerness; Sheerness Dockyard was constructed under his superintendence.

97. Was he acting there for many years as engineer for the Government?—Yes, for 30 years.

98. How long were you with your father while he was so employed?—I do not recollect now; for some years.

99. Eight or ten?—Four or five years.

100. You have practised as a civil engineer up to the present time, I believe?—I have.

101. In the course of your practice have you become conversant with the drainage of the Metropolis?—I have given considerable attention to it.

102. Have you from time to time investigated the subject for the purpose of

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forming an opinion as to the practicability of carrying out a scheme like the one proposed for draining the Metropolis?—Yes, I have.

103. Have you ascertained by borings, and by making inquiries, what strata you would have to pass through?—Yes.

104. There are several sources from whence information may be derived upon that subject?—Many; borings have been made by several parties.

105. I will ask you first, whether, for the purpose of draining the Metropolis effectually, you consider first it is absolutely necessary to have a tunnel on each side of the river?—Yes. it is.

106. Taking the northern district first; has your attention been directed to the area which will be drained by a sewer commencing at Westminster, near Westminster Hall, and ending at Barking Creek, on the north side; what area, or what number of acres would represent the drainage of that district?—There are 43 square miles.

107. What is the acreage?—Twenty-seven thousand five hundred and twenty acres.

108. Point out upon the map what those 27,520 acres would represent; would that represent an acreage drained by a tunnel ending at Barking Creek, and commencing at Westminster?—No; there is a small portion of the western extremity which is now taken by the Metropolitan Sewage Manure Company.

109. You exclude that?—Yes; we cannot take that; they having the power to do so under their Act.

110. Deducting that, it represents the acreage upon the whole of that side of the river; the north side of the river?—Yes, as far as the River Lea.

111. Where is the River Lea?—Where it is marked upon the map (*referring to the map upon the wall.*)

112. I wish to understand your limits; it commences from that point where the River Lea is marked upon the map, and then it includes Westminster, excluding that portion to which you have referred?—Yes.

113. Twenty-seven thousand five hundred and twenty acres?—Yes.

114. How many acres would be urban, and how many suburban?—There would be rather better than 11,000 acres of urban, and 16,000 of suburban.

115. Will this map assist you in explaining to the Committee (*handing a map*)?—Yes. This map shows the whole area in the jurisdiction of the Commissioners of Sewers; 11,000 acres are urban, and are represented upon this map by the yellow, and 16,000 by the red, which is suburban. There is a portion at Chelsea and the West end of the town, a district that is taken by the Counter's Creek Sewer, and a portion of the Ranelagh district which are taken by the Metropolitan Sewage Manure Company, and which we therefore could not interfere with.

116. Does the surface vary considerably above high-water mark?—Very considerably.

117. What is the highest, and what is the lowest?—The highest is upwards of 400 feet above Trinity high-water mark.

118. And what is the lowest?—Six and a half feet below Trinity high-water mark.

119. Can you state what number of acres lie below the surface of the river at high water?—Four thousand six hundred and seventy-three.

120. Trinity high-water mark still?—Yes.

121. Would the whole of that portion be subject to the evils arising from intermittent drainage?—It would.

122. Can you point out upon the plan the portions of the Metropolis which is so below the surface?—It is a portion represented with a green margin upon the plan, and is a portion of Chelsea, part of Westminster, and the eastern end of the town, the Shadwell and Poplar districts.

123. I understand you to say, that among the lowest parts of the Metropolis there would be Westminster, Chelsea, and Pimlico; would that include Buckingham Palace?—It would.

124. That lies at a very low level, does it?—Yes.

125. By the *Committee.*] I thought you said that that was a sewer you had nothing to do with, that it went to another Company?—Yes.

126. Does not that sewer, the King's Scholars' Pond Sewer, come down in front of Buckingham Palace?—Yes; those sewers could not discharge at high water.

127. You

127. You have nothing whatever to do with that sewer, have you?—Yes, we take it by means of the Victoria-street Sewer.

128. By Mr. *Hodges.*] You say there are these quantities of low level with regard to the remaining portion of the 22,000 acres; is that sufficiently elevated above the influence of the tide to discharge the sewage into the river?—Yes, it is.

129. At what state of the tide can that portion be drained?—At any time.

130. The effect of the draining the whole of this area is to convey the whole of this sewage into the Thames; do you think it therefore necessary to provide a tunnel that would carry off the whole sewage, that coming from the high level as well as the low?—Yes; I consider it by far the cheapest way.

131. Have you endeavoured to ascertain the quantity of sewage produced on the northern side of the river, and flowing into the Thames, which may be taken by the works now proposed?—I have.

132. Taking the acreage that you have mentioned, state, if you please, what is the result of the calculations you have made?—The only calculations that I have found published, which we may take as coming with authority, are those of Mr. Hawkins.

133. Was he surveyor to the Westminster Commission of Sewers?—Yes, he was.

134. Has Mr. Hawkins made a report to the late Westminster Commission of Sewers, as to the result of his gauging the different sewers?—He has.

135. Can you state in figures what the result is which he obtained?—He makes 7,045,022 cubic feet for the north side.

136. Is that cubic feet per day?—Cubic feet per day.

137. Is that on the north side, or upon the south side?—On the north side.

138. And what upon the south side?—Two millions and a half of cubic feet.

139. What is the total?—Nine millions and a half.

140. Cubic feet per diem?—Yes.

141. When was that report made?—In 1845.

142. By the *Committee.*] You stated you had ascertained the quantity of sewage, for instance, north of the Thames; have you ascertained it in any way than from Mr. Hawkins' report?—I took it from Mr. Hawkins' report, supported by that of Mr. Phillips, who was surveyor to the Metropolitan Commissioners. Mr. Phillips' is larger than that of Mr. Hawkins.

143. By Mr. *Hodges.*] Have you also ascertained it by calculating the water supply?—Yes, I have.

144. That is the best way of calculating it, is it not, in your judgment?—Yes, under the circumstances.

145. What do you find the result; what quantity of water is furnished by the water companies; is it 45 millions of gallons?—Forty-five millions of gallons; adding 33 per cent. to that, it would make nine millions and a half of cubic feet.

146. You say the water supply is 45 millions of gallons; do you add to that something for water from wells and springs?—Yes.

147. How much?—Thirty-three per cent.

148. Would that be 15 millions?—Yes, 15 millions.

149. What is the total of water supply by the water companies, and the proportion contributed by wells and springs; would that be 60 millions of gallons?—Yes, it would.

150. By the *Committee.*] You do not add anything for rain-water?—No.

151. By Mr. *Hodges.*] The whole quantity is what?—The whole quantity I have is 9,600,000 cubic feet.

152. Is that the same thing as 60 millions of gallons per day?—Yes, it is.

153. By the *Committee.*] Forty-five millions of gallons is by the water companies, and 15 millions by wells and springs?—Yes.

154. Before you gave it in cubic feet, you reduce the 60 millions of gallons to how many cubic feet?—Nine millions six hundred thousand.

155. By Mr. *Hodges.*] That would be the average flow into the river?—Yes.

156. That very nearly confirms the report you have mentioned before?—Very nearly.

157. Has there been also a report made by Mr. Phillips, the surveyor to the Metropolitan Commissioners of Sewers?—There has.

158. When did he make his report; was it in 1849?—It was.

159. What does he give as the result of his gauging the sewers?—Ten million and eighty thousand of cubic feet.

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160. Now the plan you propose is to construct the sewer so that it should run in the direction where it would be least likely to disturb the existing sewerage?—It is.

161. Do you propose to have an artificial fall commencing at the sewer at Westminster until it reaches the terminus at Barking Creek?—Taking the level of the present sewer, the Victoria-street Sewer at Parliament-street, we run with an equal fall of four feet in a mile to the end.

162. Do you consider that that will be a sufficient fall?—Quite.

163. Do you think it a fall sufficient to free the course from all deposits, so as to pass the sewage down?—Yes.

164. Would it be a rapid or a slow current?—It will be a rapid current.

165. Would the tunnel be circular?—Yes.

166. You have said it commences at Parliament-street, Westminster; would it there connect itself and form a continuation with the new sewer called the Victoria-street Sewer?—It would.

167. By the *Committee.*] When you say circular, do you mean a complete circle?—A complete circle.

168. By Mr. *Hodges.*] You say the tunnel would be connected with the sewer called the Victoria Sewer; would it carry off the contents of the sewer delivered at Westminster?—It will.

169. What portion of the Metropolis is drained by that sewer called the Victoria Sewer; can you shortly state?—It takes the drainage of Victoria-street, and of a portion of Westminster, and joins on to the King's Scholars' Pond Sewer.

170. What is the size of the Victoria Sewer at the point where you join it; do you know near about?—I have not a note of the size of it with me.

171. It is a large sewer, I believe?—It is.

172. And what is the diameter at the point where you form the junction with the Victoria-street Sewer?—Eight feet.

173. By the *Committee.*] Where is that junction formed?—At the end of Parliament-street; at its junction with Whitehall.

174. Nearly opposite the Duke of Buccleugh's house?—It is opposite the end of Downing-street.

175. By Mr. *Hodges.*] Then you proceed with the sewer until you come to Charing-cross, I believe?—We do.

176. Is there any change in the size there?—No.

177. You go down the Strand; tell me when you come to that point at which you would make a difference in the size of the sewer?—We continue the eight-feet size until we reach the Fleet Sewer.

178. Shortly state the principal sewers you would be able to intercept from Parliament-street; you communicate with the Victoria-street Sewer; you would be at a much lower level than the existing sewerage?—We should.

179. And when your tunnel is completed, all you would have to do would be to break open the crown of the tunnel, and then form a communication with the existing sewer that runs at that point; is that the mode?—We propose to carry from the existing sewers curved branches from the sides or bottom of the existing sewers.

180. Which, the side or the bottom?—According to the circumstances of the case.

181. To where?—To the side of our tunnel sewer.

182. Do you mean by curves, curved slopes?—Curved and sloping branches.

183. What is the object of that?—So as to throw the current from the branch as nearly as possible in a line with the current of the sewage in our tunnel sewer.

184. Shortly state, if you can, how many such sewers you would intercept from the point where you leave the Victoria-street Sewer; where do you meet with the first principal sewer?—The first principal one is the Regent-street Tunnel Sewer.

185. Where would you meet with that?—At Charing-cross; a large sewer comes down St. Martin's-lane to near about the same point; they would probably be both taken in by one branch.

186. By the *Committee.*] How much below the level of the Regent-street Sewer at Charing-cross shall you be?—I cannot say exactly what depth we should be below the Regent-street Sewer, as the underground surveys of the Metropolis were not open to us; we could not get the levels of all the sewers.

187. Then how can you tell whether you will be able to do so?—Because we are so considerably below them.

188. You

188. You know you will be below, but how much below you cannot tell?—We cannot tell exactly the depth.

189. By Mr. *Hodges.*] Would it be a very considerable depth below?—From 20 to 30 feet below it.

190. How much are you below the surface there with your tunnel sewer at that point?—I find we are 27 feet below the surface at Charing-cross; so that we should not be so deep below the Charing-cross Tunnel Sewer as I thought.

191. Do you know how much deeper that would be than the Regent-street Sewer?—No, I cannot say.

192. By the *Committee.*] Had you no means of getting at the depth of the existing sewer, or did you not attempt it?—I collected as much information in that way as I possibly could; but it is a very large question, and the information relating to the sewers is in the hands of the Metropolitan Commissioners.

193. Did you apply for them?—I have not applied personally, but I understand they have been applied for.

194. Do you know whether, upon an interview between Sir Charles Fox and the Commissioners of Sewers, they declined to give any information?—No; most of the communications were through Mr. Morewood.

195. By Mr. *Hodges.*] Tell me which is the next sewer you intercept after leaving St. Martin's-lane at Charing-cross?—There is a large sewer at the Savoy, which we should likewise take in.

196. By the *Committee.*] The different sewers are not marked on your plan?—They are not on our deposited plans.

197. Do you go along the Strand?—We follow along under the Strand all the way.

198. By Mr. *Hodges.*] Which is the next to the sewer at the Savoy?—The next would be at Essex-street.

199. I believe at Temple-bar you go from the jurisdiction of the Metropolitan Commissioners of Sewers, and come within the district of the City Commission?—We do.

200. Is there any considerable sewer before you come to Fleet Ditch?—Nothing between Essex-street and the Fleet Sewer of importance.

201. What sewer do you arrive at then?—At the Fleet Sewer.

202. That is a very considerable one, I believe?—I believe it is the largest in London.

203. Is that the point where you propose to increase the size of the tunnel?—We do; we increase it to 10 feet in depth.

204. You increase from eight to ten?—Yes.

205. How do you intercept that large tunnel you have spoken of at Fleet Ditch; how much are you under that sewer?—Twelve feet below it.

206. How deep from the surface?—Thirty-five feet.

207. How would you communicate with the sewer?—By a curved branch.

208. In a similar way to that you have already described?—Yes.

209. By the *Committee.*] What is the size of the Fleet Sewer?—It is in two separate branches until it crosses Ludgate-hill; and beyond there it is, I believe, 18 feet 6 inches by 12 feet.

210. Do you propose by a 10-feet sewer to take all the sewage that is brought down; that is 18 feet by 12?—No; it is very rarely that that sewer is one quarter full.

211. Do you consider that sewer much larger than necessary?—Yes, much larger.

212. Do I understand you to say that your sewer, being only 10 feet, will, for practical purposes, take everything that is brought down by the 18-feet sewer?—It will take away the sewage and ordinary rain-fall, but for flood-waters the present outlet would be left.

213. By Mr. *Hodges.*] You go on with a 10-feet sewer from that point?—Yes.

214. Then you go through Ludgate-hill to St. Paul's Churchyard?—Yes.

215. When you come through St. Paul's Churchyard, you are at a very great depth, I believe?—We are.

216. How much are you below the surface there?—Sixty feet.

217. Do you take the line of Cannon-street?—We do.

218. Do you then receive the sewer from Old Change and Walbrook-street?—Precisely so.

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219. You go under no houses there?—We keep the line of street all the way, so as to avoid interference with private property.

220. By the *Committee.*] Are there not cellars in many cases under the streets?—Yes; but in St. Paul's Churchyard, for instance, we shall be 50 feet below them.

221. By Mr. *Hodges.*] What is about the depth at Old Change, when you take in the Walbrook Sewer?—At Walbrook it is about 45 feet below the surface.

222. Do you then pass down King William-street and Gracechurch-street?—No; we cross under King William-street and Gracechurch-street.

223. Do you then take another sewer?—Yes.

224. Then you go down Gracechurch-street?—No; along under Eastcheap.

225. Do you go along Eastcheap, Great Tower-street, and Tower-hill?—Yes.

226. What depth are you below the road at Tower-hill?—Fifty feet.

227. Do you take in any existing sewers there, at Tower-hill?—The Irongate Sewer is the principal sewer at that part, which we take in; there are several others in the portion we have passed over, which we take in.

228. In what direction do you go then, after leaving the Tower?—We then pass along Ratcliffe-highway, through Butcher's-row, into the Commercial-road.

229. You are still at a great depth?—Very considerable depth.

230. Do you go on down Wells-street, Cannon-street, and Love-lane?—East Smithfield, Ratcliffe-highway, Shadwell, High-street, Broad-street, and Butcher's-row, into the Commercial-road.

231. By the *Committee.*] You make a tremendous curve here at Broad-street?—Yes; that is to avoid house property.

232. By Mr. *Hodges.*] I believe you pass under the Regent's Canal somewhere at that point?—We do.

233. Do you have any difficulty in passing under that without injuring the works of the canal?—No difficulty whatever.

234. Do you go along into Dock-road?—We do.

235. And under Bow Creek?—At the foot of the bridge we diverge from the road, so as to clear the foundation of the bridge.

236. What point do you arrive at then?—We go under some ground belonging to Mr. M'Intosh, and cross the river, keeping clear of the bend in the River Lea, and from that point we cut straight across the marshes to Barking Creek.

237. What is about the length of the tunnel?—It is upwards of 10 miles long from the beginning to the end; 10 miles 1 furlong.

238. Will you not be able to form this sewer from its commencement until you arrive at Barking Creek entirely by tunnel?—Yes, quite so.

239. You do not anticipate any necessity for open cutting at any part?—Not at all.

240. There is a clause in the Bill, I believe, prohibiting that?—There is.

241. Have you made inquiries for the purpose of ascertaining whether shafts would be necessary; have you gone into that with Mr. Ogilvie?—Yes; we have taken the average number of shafts.

242. And that is how you propose to carry away the earth which you excavate?—Yes.

243. Without interfering with the traffic of the Metropolis over that which the shafts might otherwise occasion?—Yes.

244. How many shafts do you propose in the 10 miles?—I have allowed 60 in the 10 miles.

245. By the *Committee.*] What do you mean by saying an average number?—We generally allow in estimating tunnelling an average number of shafts per mile.

246. You have distributed 60 shafts regularly over 10 miles; is that what you mean by the average?—Yes, six per mile; but when we come to carry the work out, it is probable that at some points where we should wish for a shaft, we should not be able to have one, while at another point the nature of the substratum may require them to be much nearer together, and consequently a larger number to the mile, though the average of six per mile would still hold good.

247. You tunnel after you cross the River Lea?—We tunnel the whole way.

248. You have the same number of shafts when you are in town as you have when you have gone into the country; that is, almost wholly unbuilt upon?—Under similar circumstances we should.

249. We want to know what you were doing?—It is equally necessary to have them at the same distance apart in the country as in town, circumstances remaining the same.

250. By

250. By Mr. *Hodges.*] Are they regular distances, or as near as you could place the shafts?—Wherever we could get a convenient spot.

251. You think that would be about the number altogether, do you?—I have allowed for that number. I think it is very probable, in passing through the town, we should not take above four to a mile, and in some parts not above three to a mile. I allow that number, that our estimate might fully cover the work.

252. Do you think the estimate would be quite sufficient to the number of shafts that would be required?—Quite so.

253. You have told us the quantity of sewage that you estimate to pass into the river; are you of opinion that that tunnel would be sufficient to carry away the ordinary sewage of the Metropolis?—It is more than sufficient for carrying off the present flow of sewage, together with the ordinary rain-falls.

254. Is it of sufficient capacity to carry away the flood-water also?—No, it would take away the ordinary sewage rain-fall; but the floods would pass, as they do now, into the river.

255. Supposing there is an extraordinary fall of rain, will you describe to the Committee in what manner you propose to get rid of that surplus water; suppose a heavy flood to take place, what would be the first effect of that flood on the tunnel sewer?—Upon the occurrence of a sudden flood, the first flush of water would wash all the deposit out of the existing sewers into our tunnel, which would be partially empty, and ready to receive it. Then the tunnel, once filled, and the offensive matter thus removed, the flood-water, which would be nothing more than the rain-water, will pass over into the river.

256. Would that be through the existing sewers which carry the sewage from that part to the river?—Yes; all the principal outlets would be retained.

257. You would not destroy the existing sewerage, that sewerage between the middle of the street and the river, but leave that as it is now, for the purpose of carrying over the flood-waters?—We should.

258. Describe to the Committee how that would be effected; would it be necessary to keep men to open the traps, or could you do it in any other way?—The entrance would have a self-acting apparatus to them.

259. Do you anticipate any difficulty in forming an apparatus that will effectually effect that purpose?—It may require some care and consideration before finally adopting any plan; but there are several by which it may be effected.

260. Have you any doubt about the possibility of carrying that into effect?—No doubt whatever.

261. By the *Committee.*] Will you explain where is there a self-acting apparatus which is a guide to you for the purpose of forming this?—The whole of the sewers upon the south side of the river are at present provided with similar valves.

262. Valves into the Thames you mean?—Yes.

263. Do I understand you to mean that the valves they now have into the Thames are the sort of valves that you mean to adopt for communication with the main sewer?—Probably they would be the same as these; but we have not finally fixed on the form; that being a mere matter of detail.

264. You said you would have valves at the entrance; did you mean at the entrance of the sloping channel into your tunnel; that it is there that the apparatus is to be applied?—I meant at the outlet of the existing sewers into the river there will be a valve to prevent the tide from coming back into our tunnel sewer, so that the stream coming down would open the valve before it.

265. The valves you are speaking of are valves applied at the outlet of the existing sewers?—Yes, of the existing sewers.

266. By Mr. *Hodges.*] The tunnel you propose would undoubtedly receive all the contents coming from the northern district; how would you deal with the sewerage between the tunnel and the river all along?—The distance between our tunnel and the river is but very small, consequently it would only require, either a small branch to be brought from the mouth of the existing sewers, or else so much of the inverts to be altered to throw it back into our sewer.

267. In all ordinary cases you propose to drain each side of the sewer; the river side as well as the other?—Yes, the whole area.

268. And when the flood-waters come, the works will be so constructed that the existing channels into the river, the sewers, would be opened, so that you would get rid of the flood-water?—They would remain as they do now, with the exception of having the branches from them, or a slight alteration made in the invert to give a fall towards our tunnel.

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269. You have said just now you have made yourself acquainted with the strata through which it will pass; do you contemplate any engineering difficulty in forming this work by means of a tunnel?—Not any.

270. Do you anticipate a great portion of the work will be through that which is called the London clay?—I consider the whole of it; the north side would be; you may occasionally meet with a little sand or loose earth.

271. Is clay very favourable for an operation of this kind?—Very favourable.

272. I believe that rises very suddenly from the river, does it not?—Yes.

273. By the *Committee*.] What borings have you taken to ascertain it will be all in the London clay?—We have collected various borings and information from different wells that have been sunk in the locality; and I also was furnished with some made by the City Commissioners of Sewers, and some have been taken by the promoters of this Bill.

274. Where you commence at your junction with the Victoria-street Sewer, have you had any borings there?—We have not there; I should have said there is a portion in Whitehall which will probably be loose ground; but just before we reach Charing-cross we should find the blue clay, I believe, and run it for the remainder of the way.

275. Are there a number of borings registered by the City Commissioners of Sewers?—Yes, they keep registers, I believe.

276. Have you examined those registers?—I had some of them given to me; I had not the registers to examine myself.

277. I believe they were made by Mr. Phillips, the late surveyor to the Commissioners?—No; that is a distinct set of borings; they are published.

278. Whose are published?—Mr. Phillips'.

279. I believe a special sum was voted to Mr. Phillips for the purpose of making those borings?—So I understood.

280. Have you consulted those tables?—Yes.

281. When you are conducting a work of this kind passing through this clay, do you effectually shut out any land-spring that may be above?—Quite so. We consider we should have a sufficient thickness of clay above to keep the whole of the water out.

282. Would that very much facilitate your operations?—Very much so indeed. Water is one of the worst enemies the engineer has to contend with in works.

283. And in your judgment, do you expect you will be kept tolerably free from water coming in on your works throughout the whole distance?—Yes. We should find a small quantity probably in what is technically termed pot-holes in tunnelling, but no spring or surface water would get to us.

284. How many days in the year do you anticipate, or have you anticipated, the fall of rain over the district?—That is a question which Mr. Gibbs has gone into very fully, and upon which he will give evidence.

285. About how many days in the year do you anticipate it would be necessary to use these existing connexions with the river in consequence of the flood water; it would not be very often, would it?—About 23 or 24 days in the year.

286. And are you of opinion that, with the exception of those heavy rains for 23 or 24 days, your tunnel is of sufficient magnitude to carry off the whole sewage of London?—Yes.

287. Ordinary rain-water and ordinary sewage?—Yes, quite.

288. If a tunnel were formed large enough to carry off the whole surface water in floods as well as ordinary times, do you think that would be a feasible project?—No.

289. Why not?—The expense would be most enormous, and the engine power required would be so very large.

290. It would much increase the expense of the tunnel?—Yes; I have already stated so.

291. Do you think that is a preferable plan of providing for an ordinary sewage, only leaving the surplus water to go off in the way you state?—The occasions on which storms occur are so very seldom, it would be a wasteful expenditure of capital to provide means for carrying that off.

292. Now, I must take you down to Barking Creek again; you have spoken about your tunnel to the creek; will you shortly state the sort of works there; what would the tunnel discharge itself into; a large tank?—The tunnel discharges itself into a well, from which the sewage would be pumped up into a series of tanks.

293. At what depth are you where you deliver the sewage at Barking Creek?—We are 51 feet below the surface of the ground.

294. By the *Committee.*] What are you below the Trinity level?—It might be about 67 feet below the Trinity level; the ground there is about eight feet, on an average, below the Trinity level.

295. By Mr. *Hodges.*] The sewage water would be delivered in a well, would it not?—Yes.

296. What would be the depth of that well?—It would be a sufficient depth below to allow the pumps to draw.

297. How do you propose to separate the bulky and heavy articles that come down from the liquid?—In front of the well there will be a grating to separate the matters that float down, such as will be found ordinarily in usage; such as brick-bats or stones, these would be removed by means of a dredging apparatus.

298. A dredging apparatus, at work continually?—Yes, in front of the grating.

299. What do you first pump it into from the well?—It is pumped into a series of tanks.

300. Will you describe them; give us a notion what sort of things they would be?—There are a series of tanks, side by side, into which the sewage flows; from the delivery pipe of the pump, into which there is a pipe discharging the chemical agent with which it is treated.

301. Liquid lime?—Liquid lime.

302. Would there be a series of tanks there?—There would.

303. Would that be for the purpose of precipitating the heavy masses still in the sewage?—Yes.

304. Do you know what the operation of liquid lime would be?—It would be to throw down pretty well all the deposit in the sewage.

305. Would that thoroughly deodorize the liquid?—Thoroughly.

306. What is done with that which is precipitated?—It is then taken out of the tanks and dried.

307. Is there a patent process for that?—There is a patent process, which will be described further by other witnesses.

308. What sized engines do you propose to have at Barking Creek?—We should require about 1,500-horse power.

309. Is that the amount you have estimated the expense of?—Yes.

310. Are you of opinion that would be sufficient to lift this sewage the height you have mentioned?—We should not use above 700-horse power under ordinary circumstances.

311. Why do you so much increase the amount?—The 1,500-horse power was provided to take the whole sewage the tunnel can possibly deliver.

312. You think that would be quite sufficient?—Quite so.

313. By the *Committee.*] By that I understand you to mean, that if the tunnel is filled with liquid flowing, that 1,500-horse power will be sufficient for it?—Will be sufficient.

314. The tunnel is 10 cubic feet; what amount, according to your expectation, is to be filled usually?—It would not be above a third full.

315. By Mr. *Hodges.*] These works would be considerable at Barking?—Yes.

316. The extent would be considerable?—Yes, they would.

317. How many acres?—Mr. Gibbs has gone fully into that subject, and will give the detail of the works.

318. By the *Committee.*] How many of these tanks are there?—I am not quite sure what number there are; about an acre of tanks altogether.

319. By Mr. *Hodges.*] I will trouble you, shortly, to go with me through the south side. Let me ask you first, whether the south side of the river does not require artificial drainage of this kind even more than the north?—Far more. Our works would be of far more value, as drainage works, on the south side than on the north.

320. How is that?—As I have already stated, a large portion of the northern area is sufficiently high above Trinity high-water mark to discharge the sewage at all times of the tide.

321. Is that on the south side?—No; on the south side it is pretty well all below high-water mark.

322. I believe the whole of the Southwark and Lambeth side, that part of the town, is very much below high-water mark, is it not?—From six to eight feet below.

323. Is the drainage very bad there?—Very bad indeed.

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324. Do you therefore consider a tunnel of this sort will be of very great service to that locality?—You cannot have anything to benefit the locality more.

325. Are you acquainted with that locality?—Yes.

326. Are you able to say whether great inconvenience arises now from the state of the sewage there?—We continually hear of the streets being flooded; there are many large factories there; the people occasionally had to leave off work from floods rising in the factory and driving them out.

327. For how many hours are the sewers on the Thames open on the south side?—For four hours in each tide.

328. They are open for four hours?—Yes; then they are dammed back into the sewers for eight hours.

329. That is the present state of things?—Yes; so that for 16 hours, out of every 24, the sewage is stopped.

330. Then, in case of any flood-waters, of course the state of the neighbourhood is very bad indeed?—Very bad. The sewers are already full, and the flood-waters consequently rise above the surface.

331. By the *Committee.*] What is the size of the tunnel on the south side of the Thames?—Six feet diameter.

332. By Mr. *Hodges.*] With the tunnel as you propose on the south side, will the sewers be always empty on this side as well as the other?—Always.

333. Where do you propose to commence that sewer?—We commence at the Effra Sewer, near Vauxhall Bridge.

334. If a flood takes place on the south side, or a heavy fall of rain, under your system, would the effect be to drive down all the contents of the sewers to your receptacle at Greenwich before the water began to flow into the Thames?—It would.

335. And, therefore, the result would be there the same as on the north side; the water running into the Thames would be comparatively as innoxious as ordinary rain-water?—It would be as pure as flood-waters generally are.

336. Where do you commence with this sewer?—The Effra Sewer, the principal western sewer on the southern side; we are there 17 feet below the surface.

337. Is the Effra Sewer a large sewer?—Yes.

338. By the *Committee.*] Do you mean, when you say 17 feet below the surface, that the summit of your sewer is 17 feet below the surface, or that the bottom of your sewer is 17 feet below the surface?—The bottom; the invert, or water-bed, is 17 feet.

339. Is that what you have been referring to all along?—Yes.

340. By Mr. *Hodges.*] Is the Effra Sewer a large sewer?—Yes.

341. Is it one of the principal sewers?—Yes.

342. Which course do you consider the best to take?—From there we go along New Bridge-street, and then Kennington-lane, through Lower Kennington-lane, and by Newington Butts. At the Elephant and Castle we collect several sewers. We shall have, probably, to run a branch to collect a portion of the sewers which this does not intercept.

343. By the *Committee.*] Here you intercept several sewers?—Yes.

344. Do you alter the flow of all the sewers between the Elephant and Castle and the river, in order to draw into your tunnel the sewage of the district that lies between the Elephant and Castle and the river?—Most of the sewers on the south side, or many of them, are flat, and will require no alteration; they would work one way as well as the other; where that is not the case, we have provided branches to come to the mouth of the sewer, and carry back that portion which is not intercepted by our sewer.

345. Then do I understand you there will be a double set of sewers in some cases, namely, the present sewer which carries down the sewage near to the mouth of the river, and then your intercepting sewer, which will bring it back again to your tunnel?—No; the existing sewer does not run in the same line of street as our tunnel; we have run them, as in this case, so as to collect the mouths of as many sewers as possible by one branch.

346. I understand you to say, that you would intercept the sewage that flows down the present sewer into the Thames?—Yes.

347. And that you would intercept the sewage near the mouth of the sewers?—Yes.

348. That is near the Thames?—Yes.

349. And that having so intercepted it, you would bring the sewage back to your tunnel sewer?—Back to our tunnel sewer.

350. So you bring it back in a line close to the present sewer, or in some other line in each case?—In another line in most cases.

351. Then your plan involves not only the great tunnel sewer on the south of the Thames, but a great number of other branch sewers, for the purpose of intercepting the sewage of the other sewers?—It will require two or three branches, but not more, because so many sewers on that side are level.

352. By Mr. *Hodges.*] According to the plan you propose of going to Newington Butts and the New Kent-road, where you intercept, you will be able to drain the district on either side; the side towards the river, as well as the side towards the county of Surrey?—Quite so; on one side it is intercepted by the tunnel sewer, and from the other side it is taken either by the new branch, or by reversing the current in the present sewer.

353. Would a slight alteration in the sewers between the tunnel sewer and the river enable you to get the flow into your tunnel?—Yes; it is probable in many cases it would be effected in that way.

354. By a slight alteration to the existing sewer?—Yes.

355. Then you go on along the New Kent-road, I observe; do you meet with any considerable existing sewer before you come to the Grange-road?—Yes; we intercept several large sewers there; I do not recollect the names of them at the present moment.

356. You go down Blue Anchor-lane?—Yes; and there we again intercept the Duffield Sewer.

357. What is to be the size of the sewer that commences at New Bridge-street up to that point?—From New Bridge-street to the Elephant and Castle it would be five feet.

358. Circular like the other?—Five feet circular; from there it is six feet diameter, and circular also.

359. For the rest of the distance?—For the rest of the distance.

360. When you leave Blue Anchor-lane, do you go in a direction up to the New-road; across the New-road?—Yes.

361. And then turn off at the Deptford Lower-road, do you?—Yes; run down the Deptford Lower-road, through Evelyn-street, Falcon-street.

362. What fall have you upon that sewer?—Four feet per mile.

363. The same as the other?—Yes.

364. When you arrive at the Creek, what do you do then?—After passing under Deptford Creek, we have a pumping station.

365. Will you state, if you please, why it is necessary to have a pumping station at the Creek?—We do that for two reasons; one, that we might not pass under Greenwich in the sandy subsoil, and the other that it would enable us to discharge the sewage into the Thames at high water.

366. Do you make your low level sewer a high level sewer at that point?—Yes.

367. That is the effect of your pumping apparatus?—Yes, it is.

368. What engines have you provided for working the pumping station?—We should require 189-horse power for the ordinary flow of the sewage, or 400-horse power to take the whole discharge of the sewer.

369. How deep are you below the level at that point?—The lift would be 37 feet.

370. You would have to lift the whole of the sewage 37 feet?—Yes; the whole of the sewage 37 feet.

371. Would you discharge the contents of the sewer, then, into the high level sewer?—Yes.

372. How deep would that be below the surface, the commencement of the high level sewer?—The first short part would be embanked over. The bottom of the sewer would be about one foot below the present surface; the remaining portion would be embanked over.

373. In what direction does it pass?—It passes then under London-street, under some private property, into Burney-street, and then under the foot of Greenwich Park.

374. It passes through Greenwich Park?—Yes.

375. What is the depth in passing through Greenwich Park?—Upwards of 30 feet.

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376. It cannot interfere with the roots of the trees?—Not at all.

377. Does it go under Maze-hill?—Under Maze-hill.

378. And across the Marsh to Green-lane?—Yes.

379. There, I believe, you pass under some market-gardens?—Yes; and across the Greenwich Marshes to the terminal works on that side.

380. Would you have to interfere with the Woolwich-road?—It would require to be raised about six feet.

381. Could that be easily done, without causing any injury?—Yes; it is a thing commonly done in carrying out railway works.

382. By the *Committee.*] Whereabouts is Mr. Hargrave's property?—At the point where the lift is.

383. By Mr. *Hodges.*] You cross Greenwich Marshes, I believe, by embankment?—We do.

384. And you arrive at a place called Horn-lane?—Yes.

385. What will be the depth below high-water mark, at the point where the works reach the river at Horn-lane?—About six feet below high-water mark.

386. Do you require any pumping there?—No; it would discharge into the reservoir.

387. And would you have a system of tanks, similar to those on the north side?—The works would be precisely similar to those on the north side.

388. With this difference, there you would not require pumping?—It is possible, in the process of manufacture, we might find an engine convenient if in altering the shape of any of the tanks, if we thought it desirable to have them higher than that at which the sewer would deliver.

389. What steam-engine would you require there for the manufacture of manure; have you made a calculation of that; further evidence will be given on that?—Yes.

390. Do you consider this, on the whole, the best course to take for the purpose of draining the south side?—Yes, I do.

391. Do you think it preferable to following the course of the river exactly, as you have done on the other side?—Yes; if we had followed the course of the river as on the other side, with the same fall, the lift at the station would be considerably more than we have now.

392. Do you consider that when you have the tunnel sewer made you would be able to drain thoroughly on both side of the tunnel?—Thoroughly.

393. The river side as well as the other?—Thoroughly.

394. Have some calculations been made with a view of ascertaining the expense of the necessary works, the alteration of the sewer and other works, to drain that part between the tunnel and the river?—Yes.

395. What is the amount; have you taken the amount of the estimate, the account of the alteration for the purpose of draining the area between the river and the tunnel sewer on the south side?—I have allowed rather better than 13,000 *l.*

396. By the *Committee.*] Is that for both sides, or for one?—For the south side.

397. How much for the north?—Sixteen thousand pounds. That, I should say, includes valves at the mouths of the existing sewers.

398. Valves and alterations in the inverts, or substitutions for such alterations?—Precisely so.

399. By Mr. *Hodges.*] Are you of opinion the sewer would be sufficiently capacious to carry off the ordinary sewage and the ordinary rain?—I am.

400. It would not carry off the flood-water?—No, the flood-water on the south side would pass off in a similar manner to the north by the present existing outlets.

401. Have you made an estimate of the cost of this work?—I have.

402. Does it agree with Mr. Brassey's or not?—I believe so.

403. Is this your estimate?—Yes.

404. It differs a little from Mr. Brassey's, does it not?—I did not see what estimate Mr, Brassey had.

405. Have you gone carefully through the cost of all these works?—Yes.

406. So much for brickwork; do you consider this would be a sufficient sum to perform all the works mentioned here?—Yes.

407. What is the amount?—The total amount is 980,000 *l.*, within a few pounds.

408. By

408. By the *Committee.*] Nine hundred and eighty thousand pounds for works?—Yes, to complete the whole.

409. By Mr. *Hodges.*] What are the works on the north side?—On the north side will be 632,000 *l.*

410. And the south side?—The south side will be 330,000 *l.*

411. You have put down for legal and Parliamentary expenses something?—Yes, 15,000 *l.*

412. Contingencies, I suppose?—Yes.

413. By the *Committee.*] Does the 15,000 *l.* take Parliamentary expenses and contingencies also?—It includes expenses up to obtaining the Act.

414. What do you allow for contingencies?—The contingencies are allowed in the estimate of the whole of the 57,000 *l.* for the north side, and 30,000 *l.* on the south side.

415. Then your estimate for the north side, which is 632,000 *l.* includes the 57,000 *l.* for contingencies?—It does.

416. Then it differs materially from Mr. Brassey's estimate, because he took for the north side 658,000 *l.* without the contingencies?—I do not know what he includes in that sum.

Cross-examined by Mr. *Gurney.*

417. I suppose you have all that in detail?—Yes.

418. I could have a copy of that, and cross-examine to-morrow; that would be convenient. While we are fresh on the south side, Mr. Mitchell, you say you commenced upon an embankment at Deptford?—Yes.

419. Do you provide at all for draining the town of Greenwich?—Yes; Greenwich would be drained back to our well, at our pumping station.

420. Which part of your tunnel would provide for Greenwich?—It would cut off all the upland water that comes down, passing through Greenwich Park.

421. What Greenwich sewer could communicate with your tunnel?—None of the sewers would communicate with our tunnel.

422. None of the sewers at Greenwich could be made to communicate with your tunnel in any way?—Not into the tunnel itself.

423. The whole town of Greenwich would remain as it is now?—No; we afford means for its being drained, by providing an outfall at our pumping station.

424. You are upon a higher level, are you not?—But we have our low level sewers within reach.

425. Have you two tunnels there?—The low-level sewer terminates at Deptford Creek; there the sewage is pumped up into a higher level and conveyed into the river.

426. Do you afford means for draining into your tunnel for the town of Greenwich?—We do.

427. I understood you do not; it does not appear upon your plan in any way, does it?—Yes.

428. By the *Committee.*] You say your level would afford convenience for the process to take place?—Yes.

429. You do not propose to do it, but you say this lower level is such that the sewerage of Greenwich might be drained into it?—Yes, with greater facility.

430. By means of new sewers?—Or by altering existing sewers.

431. Have you looked to see what alteration would be necessary at all?—No.

432. It does not form any part of your scheme: taking the sewage of Greenwich, it is not included in this plan?—So far as the pumping station is there ready to receive anything.

433. I understand you cannot state what would be the expense of forming a communication between the existing sewers and your tunnel?—I cannot.

434. You have not made any estimate for the expense of communicating with the Greenwich sewers?—No.

435. Have you considered whether there is any practicable mode of doing it?—It can be drained back, as I stated, into our pumping station.

436. Do you think that will be a very convenient mode?—I think so.

437. But you have not considered the mode you can recommend for that, have you?—I have always considered that was the way it would be carried out; we should not be allowed to interfere with the general sewerage.

438. You spoke of the Effra Sewer; do you know the size of the Effra Sewer?—I am not sure what the size is; a portion of it is open drain.

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439. What is the size where it is not an open drain, and where they join?—I do not recollect what it is.

440. Do you not know at all what the size is; is it about 14 feet diameter, 14 by 13?—Probably it may be.

441. And your sewer, which is to carry off all the Effra Sewer brings, is five feet diameter?—No; our sewer is not to carry off all the Effra brings.

442. What is it to carry off?—To carry off the ordinary sewage, and a common quantity of rain-fall, the same as upon the north side.

443. Your sewer, where it communicates with the Effra Sewer, is five feet, is it not?—It is.

444. That being nearly 14 feet diameter?—Yes.

445. Do you know whether that is sometimes full?—Probably it may be.

446. Do you know how often in the year it is full?—No.

447. Have you paid any attention to see the quantity that is brought through that sewer?—I have not distinguished that sewer from the other ones, but I consider that when it is running full, the sewage would be so diluted that it might pass into the river without detriment.

448. Have you observed it at a time when it is full, so as to observe how that is?—I do not know that I have.

449. How long have you been engaged upon the plans here?—I have given the last 12 months entirely to it.

450. The last 12 months exclusively to this?—Yes.

451. Have you not thought it desirable to see what is brought through the different sewers which you are to carry off?—Yes; I have examined them all as far as I can.

452. You say you have never seen the Effra Sewer full; how often have you been to see that?—I am sure I cannot say.

453. How many days in the 365?—I do not know, I am sure.

454. Have you ever gone to look at it when it was likely to be at the fullest?—I have gone to all of them on different occasions.

455. Can you tell us when you have been; give us any time when you have been to the Effra Sewer?—No; I do not know that I can mention any particular occasion on which I have been there.

456. Have you been with the view of ascertaining the greatest quantity that comes by it at any time?—No; only in connexion with the whole plan; I have not selected that sewer for particular observations.

457. Is that the case with respect to all the other sewers too; have you ever been to see what is the quantity that comes down through the other sewers?—Yes; I have examined the whole of them, as I stated before.

458. Have you ever gauged the quantities passing through them?—I have no power of doing so.

459. You have never done it, then?—I have not.

460. Have you ever applied for leave to do it?—No.

461. Do you not think that would be a safer mode of ascertaining than by a general theoretical calculation of your own?—It ought not to be safer than depending upon the Commissioners' own gauging.

462. You do not quite depend upon the Commissioners, as I understand you take some other quantity?—We take another quantity to confirm it.

463. You take another quantity to contradict it, do you not?—I think not.

464. The quantity from the Commissioners does not agree with the quantity you gave yourself?—I think you will find that it very nearly agrees.

465. What do you give as the quantity on the south side of the sewage per day?—Better than two millions and a half of cubic feet.

466. Is that taken from the Commissioners in any way?—Yes; Mr. Hawkins' gauging gives that.

467. That gives two millions and a half to the south side, does it?—Yes; he gives nearly two millions and a half.

468. Who was Mr. Hawkins?—He was surveyor to the Westminster Commission of Sewers.

469. Do you reckon that there would be an equal portion throughout the 24 hours?—No.

470. You must provide for the greatest quantity at any period of the day?—Yes.

471. In what proportion do you reckon the whole quantity is carried through

in

in the course of six hours together in the day?—I should think about half the quantity would be carried through in eight hours.

472. Is not half the quantity carried through in six hours?—I should think not.

473. Have you made inquiries to ascertain that?—I have.

474. What inquiries have you made?—I have gone upon the experience in towns where they have a constant supply of water.

475. Here there is not a constant supply in London, is there?—But the effect would be the same. If the water is not drawn from a constant supply system, it would be drawn from the tanks at the same hours.

476. Is that so; where there is a constant supply there is a certain quantity overflowing the whole time, is there not?—No.

477. You think that affords a means of ascertaining the quantity?—I do.

478. What towns are they that you have made inquiry about, and ascertained that only one-half passes in eight hours?—There are one or two towns given in the report of the Board of Health.

479. I want to know what your materials are; is it from the report of the Board of Health you have ascertained that one-half passes in eight hours?—Partly from statistics published in them.

480. Can you refer me to the report?—I have a note with me as to which report it was.

481. Probably you can furnish me with that to-morrow?—Yes.

482. Which are the hours during which you imagine there is the greatest flow?—I think it is about four in the afternoon that the greatest flow is, for about an hour.

483. Which are the eight hours?—It is not during eight consecutive hours that the maximum discharge takes place, but for one or two hours only out of the 24, during which the sewage flows off in greater or less quantities.

484. Can you tell me what is the proportion of a whole day's flow which passes through in any one hour?—It is equal to the whole discharge in 16 hours.

485. Supposing that there is 1,000 cubic feet passing in the 24 hours, what proportion of that passes in any one hour, the hour of the greatest flow?—I am not sure what that quantity would give; I can supply you with it to-morrow.

486. It is material, in order to calculate whether your sewers have sufficient, as you have to provide for the greatest flow at any part of the day; cannot you tell us what you have reckoned to be the flow at one hour?—It might be equal to the whole discharged in that time; that is, the maximum flow of the whole quantity discharged in 16 hours.

487. Do you mean the whole quantity discharged in 16 hours; if there were an equal flow during 24 hours, it would be 1-24th part of the whole; I want to know what period it flows in the one hour?—If you take the maximum flow, and the sewage continued to flow at that rate, the whole would be discharged in 16 hours, instead of being distributed over 24 hours.

488. One-sixteenth passes through in the hour of the greatest flow, do you mean that?—Yes.

489. Have you based your calculation upon that, when you have spoken of this being sufficient?—Yes.

490. What is the quantity, then, that you reckon; the greatest quantity; I forget the quantity you gave us in 24 hours?—There would be near 18,000 cubic feet per minute discharged upon the north side.

491. And how much upon the south?—And upon the south there would be between 2,000 and 3,000 cubic feet per minute.

492. You have spoken of having taken these calculations from some returns; Mr. Hawkins' returns; when were they made?—In 1845.

493. Have you reckoned upon any increase in the Metropolis returns in that time?—There would be an increase, certainly.

494. Have you included that; have you made any allowance for that?—Yes.

495. What increase have you allowed?—There is a slight increase given in our quantity.

496. I was not aware that any was given; tell me what you allowed for that, and what is Mr. Hawkins' quantity?—Mr. Hawkins' quantity is 7,000,000 upon the north, and 2,500,000 upon the south.

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497. Mr. Hawkins' was in 1844, was it not; you stated in 1845?—He gave his evidence in 1845.

498. His gauging was in 1844?—I am not sure.

499. What is the quantity you have taken?—Nine million six hundred thousand cubic feet.

500. For the north side?—For the whole.

501. What you have taken for the north side; Mr. Hawkins' is 7,450,000?—It gives about 7,500,000.

502. Do you mean the difference between 7,450,000 and 7,500,000 is what you allow for the increase of the population in the last nine years?—No.

503. How is it, then, you say you have allowed for that?—Because I consider that Mr. Hawkins' gauges at that time must have been in excess of the actual quantity.

504. What makes you come to that conclusion?—I can see no source from which the quantity of sewage could be derived.

505. Then your estimates are not founded upon the gauging of Mr. Hawkins?—They are founded upon what I deduce from Mr. Hawkins in comparison with the water now delivering in.

506. You say you have made an allowance for the increase of population in the last nine years; how much have you allowed for the increase in the population for the last nine years?—We consider the taking the water supply, and allowing 30 per cent. upon it, we get as fair a quantity to represent the discharge of the sewers as can possibly be arrived at.

507. You have made an allowance, in fact, for the increase of population in these calculations?—That is the quantity which we take.

508. Was it a mistake when you told me that you had made an allowance for the increase of population, or not?—We consider that that covers the whole; we make an allowance in that way.

509. You have not in your calculation made any allowance for the increase of population since the time Mr. Hawkins made his estimate?—We take the water now supplied into London, and allow 30 per cent. for other sources; we consider that we get then quite as much as the other way.

510. That is another mode of arriving at your result; you told me just now you confined your estimate to Mr. Hawkins, and that you had made an allowance for the increase of population since Mr. Hawkins made that calculation; is that true or not?—It is not founded entirely on the one or the other; it is a most difficult point to arrive at.

511. And there is no place where you have made any allowance for the increase of population since Mr. Hawkins' estimate?—We make an allowance in that way; we consider his estimate was in excess at the time he took it.

512. And therefore you make an allowance for the increase of population by making a deduction from his estimate; is that what you mean; does it work it so?—We confirm the one calculation by the other; by trying it in several different ways we find it comes nearly to the same thing.

513. With respect to that other mode, which you say is the better mode of making it, you say the supply by the water companies is 45 millions of gallons?—Yes.

514. Where did you get that from?—From the returns.

515. From what returns?—It is in the Parliamentary books.

516. Where did you get this?—I have had it by me for some time.

517. Forty-five millions from the New River, from the River Lea, the Thames, and Ravensbourne; is that it (*referring to the Minutes of Evidence by the Water Committee*)?—Yes.

518. The other, I suppose, being supply from wells, and so on, in conjunction?—Yes; we can find no register of that.

519. You say that your sewers are provided for the ordinary rain?—Yes.

520. What do you call ordinary rain?—We refer to the rain tables, and find there that a quarter of an inch rain-fall does not occur for more than about three or four and twenty days in the year.

521. You provide for all but those 23 or 24 days upon which more than a quarter of an inch falls?—Yes.

522. What quantity does the quarter of an inch rain-fall give you?—Over the whole area?

523. Yes?—We do not take the whole area, because there is only a portion of it which will come into the sewers.

524. What portion do you take that will come into the sewers?—That is a branch of the subject which Mr. Gibbs' evidence will be directed to more than mine.

525. You have given an estimate of the quantity which these sewers will carry; what is the quantity you reckon will be produced by a fall of a quarter of an inch?—The whole of the rain-fall question has been gone into by Mr. Gibbs, who confirms my previous calculation, and his evidence will give you all the particulars upon the subject.

526. You assume the correctness of the evidence he will give upon that subject?—Yes; he has gone into it fully.

527. This is not the account given by the companies of their quantity of water (*referring to the Minutes of Evidence by the Water Committee*)?— I think you will find a table at the end giving the totals.

528. Is it from this you speak, or from some table?—It is from a table at the end.

529. This is a calculation made on the water supply by a superintendent inspector; there would be a considerable difference as to the quantity of water at different parts of the year; it is not equably through the year?—I do not know the precise variation.

530. You probably do not know whether the New River Company, which is there put down at 15,000,000, is now delivering 20,000,000?—No; I presume the statement there is correct.

531. Do you suppose, in 1853, they are delivering the same quantity as in 1849?—There would be some increase; and it is considered in the 33 per cent. allowed in addition to those returns.

532. Have you provided for any prospective increase in the metropolis?—We have in the tunnel.

533. What increase have you provided for?—We consider that the tunnel will take all the sewage for some 30 or 40 years to come.

534. What is the increase you reckon upon in quantity in 30 or 40 years?—It will allow it to double.

535. You think that any scheme ought to provide for double the quantity that is now carried?—It would be well that it should.

536. And it ought to do so. You reckon upon its being doubled in the next 30 years?—Forty years.

537. And you have provided for that time?—Yes.

538. Tell me what is the relieving power of the tunnel per minute upon the northern side?—Twenty thousand cubic feet.

539. And that is with the tunnel gorged?—Running full bore.

540. As full as it could be able to run?—Yes.

541. Do you reckon upon any impediment from obstruction in ballast, or such things brought into the sewers?—We consider that that would all be washed out by the current.

542. What is the velocity?—The velocity will be nearly three miles an hour with an ordinary flow.

543. When it is half full, is that so?—It would be about a third full under ordinary circumstances.

544. With it a third full you reckon it would have a velocity of three miles an hour?—Nearly.

545. Supposing, when it gets nearly full, as full as it can be, what will be the velocity then?—I am not prepared to say; the velocity would be greater.

546. Would a speed of three miles an hour be sufficient to carry off all the material that would be brought into the tunnel?—It is generally considered so.

547. Do you consider it so?—I do.

548. Have you any opinion upon it?—Yes; I have given you it.

549. Can you state what you think would be the difference of velocity between it full, half full, and a third full?—No; I have not the calculation with me.

550. About what?—It is no use stating any proximate quantity in calculation; I can supply you with the actual velocity, if you wish it.

551. Where would you get it from?—By calculating it.

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552. Do you profess to have any opinion yourself upon the subject?—Yes.

553. You say you can procure it?—Yes; but I have not it with me at present.

554. Whose opinion is it you will procure upon the subject?—I should give it to you. I have gone into all this; unless I had known the velocity I could not have told you the actual discharge of the tunnel.

555. Can you tell me what the difference would be supposing it is half full, or full?—I have not it here.

556. Do you mean you have made a calculation of what the velocity will be at both periods?—Yes, or I could not have decided upon the right size for the tunnel.

557. And that calculation you will give me?—Yes, I will.

558. What is the delivering power upon the south side?—Upwards of 5,700 feet a minute.

559. That is supposing it to be full?—Yes.

560. What is the velocity to be there?—The velocity there would be somewhat less than upon the other side; I have not with me the actual velocity.

561. Is it materially less?—No; it might be two miles and a half.

562. What is the fall upon the south side?—Four feet a mile.

563. Four feet a mile upon both sides?—Yes.

564. With respect to the means of preventing the ingress of the tide, I understand you to say, that there are several descriptions of valves which you say might be used?—I feel no doubt upon that point myself, but what it could be done.

565. Are they single valves or double valves that you would use there?—I have not determined upon that yet.

566. It may materially affect the expenses, may it not?—We have allowed ample in the estimate for covering that.

567. Have you allowed for single or for double?—We have allowed a price which we consider would cover either.

568. It would be a very different price, would it not, according to what you have?—Yes; but unless the circumstances of each valve were gone into separately in detail, you could not arrive at an accurate estimate in that respect.

569. Do you mean you would have different valves in different parts?—According to the circumstances of the case.

570. You do mean that in many of the sewers there would be single valves and in some double?—Yes.

571. What proportion of them would be double?—I cannot say at present; it is matter of detail which would have to be settled in carrying out the plan, but it is to our interest, and, in fact, we could not carry on our works without we do make them tight; there is no doubt but that we should do that, and do it effectually.

572. It will make a considerable difference in the expense, will it not?—Not very material.

573. What have you reckoned upon in your estimate; what proportion to be single, and what proportion to be double?—I have not separated them; but I have taken a price which I consider would cover either case.

574. You have taken the price per valve, which would cover each?—Yes.

575. Or have you taken it in the gross?—Taken the price per valve.

576. What is the amount you have given for that?—I have allowed 100 *l.* a valve. At the Fleet I have allowed 500 *l.* for the valves.

577. How many valves have you reckoned?—On the north side there would be about 20; 21 including the Fleet.

578. Twenty, you take at 100 *l.* each?—Yes.

579. Is that 100 *l.* sufficient for the single or double, do I understand you to say?—I consider that it would cover either; I consider it would provide a valve which would act effectually.

580. I want to know the description of valve; you said there would be some single and some double, as I understand?—No; that was your question.

581. And you said "Yes" to it?—I said we should provide a valve which would do its work effectually.

582. You said you would have it sometimes single valves, and at some double?—And it is probable that we should.

583. Is

583. Is it so, or not; or is it to be taken both ways?—It is a point of detail which we cannot settle at present.

584. You do not know whether you could even have a double valve?—I provide a price which I consider would bear the whole; I do not consider that 100 *l.* would cover the valves at some points.

585. What would be the difference in expense between double valves and single?—I am not sure what the expense is.

586. Do you know the expense of either?—I go from general experience in such matters, as to what would cover it.

587. That leads me to ask what your general experience in such matters has been; what has been your general experience in such matters?—If you put a question which is capable of being answered, I shall be most happy to do so.

588. Can you not tell me what experience you have had in works of this description; you say you go from your general experience in such matters; have you ever constructed any similar works?—I go by the experience of others as well as myself as to price.

589. You say you judge from your general experience in such matters; I ask you what experience you have had?—You misunderstood me, if you consider I am not going on my own experience.

590. What experience have you had in such matters?—In drainage works?

591. In works similar to these?—On dock works we meet with precisely the same things.

592. What works have you ever constructed?—I have been engaged upon different works.

593. Have you had the superintendence of any works of this description?—Yes.

The *Committee* inquired whether the parties for whom Mr. Gurney appeared were testing the accuracy of the details, or whether they were opposing altogether the Preamble of the Bill, with a view of showing that the project ought not to be carried out.

Mr. *Gurney* stated that he was opposing the Bill with the latter view.

Mr. *Henderson* stated that, appearing for the Metropolitan Commissioners, if in the result of the inquiry they felt that the public interests would be consulted, their opposition would be withdrawn; but that with regard to the guarantee of 3*l.* per cent., that was objected to by all parties.

[Adjourned till To-morrow, at Twelve o'clock.

Martis, 7° die Junii, 1853.

LORD SEYMOUR IN THE CHAIR.

Mr. *John J. Mitchell*'s Cross-examination, resumed by Mr. *Gurney*.

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594. I WAS just asking you as to your experience in works of this description previously; can you tell me of any works similar to these that you have been engineer of?—My experience has been of a general character.

595. Will you tell me what works you have been engineer to?—I have formed on my account, as resident engineer, between 60 and 70 miles of railway.

596. Have you ever been principal engineer to any works?—No. Resident engineer is much in the same position.

597. You have been resident engineer in 60 miles of railway?—Between 60 and 70.

598. Where was that?—In Norfolk and Suffolk.

599. What lines were they?—The Ipswich and Bury.

600. Under whom were you there?—Mr. Bruff.

601. Is that your whole experience?—No; I formed the Ipswich and Norwich line afterwards.

602. Is that part of the 60 miles you have spoken of?—Yes, it is.

603. During what time is it you have been engaged on those works?—About five years.

604. The last five years?—No.

605. How long is it since they were completed?—About two years.

606. Can you mention any other works on which you have been either principal or acting resident engineer?—I have been with several large engineers; I was with Mr. Page for some time.

607. How engaged with them?—I have been engaged under them.

608. Have you been engaged in their offices?—In different capacities; whatever they have required me to do.

609. Have you had the superintendence of other works than those you have mentioned, the 60 or 70 miles, and the railways in Norfolk and Suffolk?—No.

610. Were there any difficult works in the Norfolk and Suffolk?—Yes, there were.

611. Tunnels?—Yes, one.

612. What is the length of any tunnel there?—About 320 yards.

613. Where was that?—At Stoke Hill.

614. Through what sort of soil was that?—Through varied soil; clay and shale.

615. As to this estimate you have handed in, which has unfortunately only just come to me, tell me what you include in that estimate; do you include any works except those marked upon your plans?—This includes the whole of the works contemplated under our Bill.

616. Does it include any except those marked upon your plan?—They are not all shown; the branches and connexions are not shown on the plan.

617. This estimate includes all the estimate of connexion of your tunnel with the present sewers?—Yes.

618. By the *Committee.*] What do you make your estimate for the junctions?—On the north side, 16,000 *l.*; on the south side, 13,500 *l.*

619. By Mr. *Gurney.*] Does that include, for instance, the connexion you spoke of yesterday with the Greenwich sewer?—No.

620. Are there any others of which you have spoken which that does not include?—It includes everything.

621. It includes everything, except the connexion with the Greenwich sewers?—Yes.

622. All the branches on the south side?—No. They are all allowed for in the body of the estimate.

623. But your estimate of expense does include them?—It does.

624. You

624. You mean that that does not come in, in the item you have just spoken of, in the 13,000 *l.* and the 16,000 *l.* ?—Exactly so.

625. You propose to take houses, do you not; on the north side we will take first of all; you propose to take houses in order to sink shafts?—Not in all cases.

626. But in many cases?—Where we cannot get a spot without.

627. For the first few miles from Westminster, do you not propose to take houses?—No, not in all cases; there are many spots where we could have a small hoarding, the same as is now commonly put up.

628. I understood the works were to be constructed without interfering at all with the highways, in consequence of having shafts, by taking houses at the side? —No; a hoarding would be put up where it would not materially interfere with the highways.

629. You told us you were going to have these side-shafts 60 in 10 miles upon the average; six to a mile?—That is the number allowed in the estimate; but there would not be so many as that used in passing through house property.

630. What number do you propose in the first four miles, say?—It is impossible to say until we actually go into the works.

631. About what number do you estimate for?—I have allowed that number over the whole.

632. Have you allowed that number for passing through the house property? —The first four miles I have; but one part may compensate for another.

633. Have you reckoned upon as many as 24, while you are passing through the house property?—I have reckoned upon 60 for the whole length.

634. Have you reckoned upon the same proportionate number while passing through house property?—I have not divided them.

635. How many have you reckoned for in the first four miles?—I told you I have reckoned for 60 in the whole length; we possibly might not require them.

636. Do the first four miles require as many as the last six in proportion?—It is impossible to say until we go on with the works.

637. What is the sum that you have allowed for houses you would have to take?—We have allowed 4,500 *l.* on the north side.

638. Is that for the whole 10 miles?—No; there is another item that would partly cover that.

639. Tell me what you have allowed for all the houses and plots of ground you have to take in order to make side-shafts?—I cannot enter into any detailed estimate of that until we know the actual spots.

640. Surely you have estimated some sum for plots of ground and houses you take for your side-shafts; you said 4,500 *l.* is allowed?—Yes.

641. What for?—For plots for side entrances.

642. Is that the whole you have allowed for 60 side entrances?—£.4,500 is for the south side, and it is 8,000 *l.* for the north side.

643. That takes in 60?—Yes.

644. Do you consider that 8,000 *l.* would be sufficient to cover it?—Yes; I consider that sum would.

645. What would be your plan; how would you proceed; would you take a house, and then form a shaft down; you would have to pull the house down, I suppose?—No.

646. Pretty nearly?—No; in all probability we should not interfere with the house at all; we could get a small piece of ground behind; and could form a shaft there.

647. Hardly that through the streets of London, would you; what would be the size of the mouth of the shaft?—Nine feet.

648. You do not find many spots of that sort in back yards of houses in London?—We find many places where there would be no objection to a shaft of that description being sunk to carry out a great public work of this kind.

649. How would you carry the contents of the tunnel away; through the houses?—It would be carted away; be raised by steam power, and discharged into carts.

650. Then you would have a steam-engine round the mouth of the shaft?— There would be a small portable engine, similar to that which was for some time standing in use in Piccadilly a few months since.

651. You reckon on carrying the soil through the house; the house is to be left standing, and the soil to be carted away?—When the house is taken, the soil

Mr. *J. J. Mitchell.* would be raised and discharged into a cart, either through the house, or behind the house, wherever the most convenient spot would be.

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652. Have you considered what number of houses you would have to take in passing through the City of London?—No; I have not gone into that in detail.

653. How have you arrived at your estimate of 8,000 *l.*?—Before settling the estimate, I consulted with Mr. Haywood, the City surveyor, on that point, and he told me he thought there would be no interruption to the public at all.

654. That what would not?—These works, if properly carried out, under a proper supervision.

655. How does that enable you to arrive at 8,000 *l.* as the proper sum?—I considered that he could provide us with a sufficient number of sites, or nearly so.

656. Did Mr. Haywood tell you he could provide you with sites?—Not that he could, but we might have them without prejudice.

657. That you might purchase these side plots without prejudice; he did not say you would only have to pay 8,000 *l.* for them?—No; but he said there were many spots in the City where we could have our shafts without greater inconvenience than is now caused.

658. Am I to understand my friend was mistaken in his opening, and that it was not intended to have these shafts from houses, in order to avoid any obstacle to the public?—It was intended to have them wherever obstacles might arise; but for instance, in Farringdon-street, where the cab-stand is, there is a greater width of street than the traffic requires; you may put down a shaft there without inconvenience to the public.

659. Do you mean you could have a shaft in the middle of the street in many places in the City of London, and a steam-engine at work without any inconvenience?—We have seen the same thing done in London within a very short time.

660. Could that be done without inconvenience?—We very often have streets closed for far less important works than these.

661. But it is not done without inconvenience?—There must, of course, be some small portion of inconvenience, the same that is experienced in carrying out all large works.

662. Am I to understand you calculate on having these shafts in the middle of streets, and not in houses?—No; you are not to understand that.

663. What number of houses do you propose to take for side-shafts?—I cannot say, without going into more minute calculations than are necessary for the present inquiry.

664. Do you reckon upon generally having them in the streets, or not?—We should certainly have them in the street, if we could, without inconvenience to the public.

665. Do you reckon you would be able generally to do it without inconvenience to the public?—In many cases we should.

666. Do you mean generally, in the majority of cases or the minority; what is to be the rule, and what the exceptions?—It is impossible for one to speak specifically on a point of that kind, without going the whole length of the line, and making very minute inquiries.

667. And that you have not done before you fixed the sum of 8,000 *l.*?—No; and I have not put an advertisement in the paper advertising for plots.

668. How did you arrive at the 8,000 *l.*; you began by saying something Mr. Haywood told you?—After I had had that conversation with Mr. Haywood, I felt that there would be no objection on the part of the authorities to our having a shaft in the street, where it would not materially interfere with the traffic.

669. Then how did you arrive at the sum of 8,000 *l.*?—The sum of 8,000 *l.* is fixed principally from my judgment in the matter.

670. Is that a guess?—No, decidedly not.

671. What is it then?—There is a difference between judgment and guess.

672. Tell me on what data you have proceeded?—I have been endeavouring to make you understand.

673. Will you tell me how many places you reckon upon you would be able to do it without inconvenience to the public, and without objection by the authorities?—I told you that I considered that sum would be sufficient to cover the expense in going through; but as to entering into detail, it is a matter which neither I nor any other man can.

674. You cannot give me any other reason for supposing that to be a sufficient sum?—No reason than that of experience; general experience in the matter.

675. You have no compulsory powers by your Act to take houses or land?—Not to take houses in those cases; I believe not.

676. Not for side shafts?—I do not know. Mr. Hodges stated there was no compulsory clause to take houses for side shafts.

677. What is your plan for ventilation of your tunnels; have you any plans for that?—We should ventilate it in a very similar way to that now adopted through a railway, and where possible, to carry it up by a shaft.

678. Do you propose to have openings at certain distances all the way along?—Yes, similar to those in the present sewers.

679. That you propose to have all along the length of this tunnel?—In many parts it would be necessary, but the tunnel will not require ventilating so much as the present sewers, for this reason, we shall have no deposit in our tunnel.

680. Will you tell me what your plan is, if you think it necessary to ventilate?—It will be necessary at given intervals to leave an air shaft.

681. Do you propose to have a shaft carried up to any height, or do you propose merely to have like holes in the present sewers?—If circumstances would permit, we should carry a pipe or shaft up to the top of any building which may be near.

682. That you think would be a desirable plan?—No doubt it would be desirable in all cases if it could be done; if it is not objectionable for the grating to open into the street, as in the present sewers.

683. It is considered an objection?—They still continue the practice; I believe they are putting them in still.

684. Have you formed any idea as to the quantity of ballast and drift that will be carried into your tunnel?—There will be a considerable quantity, no doubt.

685. Have you made inquiries to ascertain the quantities that are carried into the sewers now?—The quantity is stated in some of the Blue Books.

686. Will you tell me what quantity you have reckoned upon here?—I have not made a calculation of that.

687. Will it not a little affect your working at the reservoir, the quantity that is carried?—No, not at all.

688. Not whether you have 500 tons or 1,000 tons of this stuff carried to your reservoir?—It is the difference of power in raising it; there is the dredging machine there; it could not come down in such large quantities but that will take it up.

689. Explain your mode of working at the reservoirs?—It is the same as I explained yesterday: that in front of the pump shafts there is a grating to arrest the passage of all heavy or floating bodies that may be brought down, and in front of that grating there would be a dredging apparatus, which would bring up any matters brought against the grating.

690. Which do you call your front?—On the tunnel side.

691. Would there be an apparatus for lifting that?—There would.

692. So that it should not pass into the reservoir at all?—No.

693. Have you the plans of the apparatus at the end?—Detailed plans?

694. Yes?—I have not any with me.

695. Have you not any drawings, or anything representing what you have there?—No, I have not.

696. How would you avoid, in lifting up the sewage, lifting up the road-drift and ballast?—It would be avoided in the same way that dredging machines in the river do; they bring up the clear ballast, but no water with them.

697. I am not speaking of water, I am speaking of sewage?—The sewage would be mixed with water, and would not separate until it had passed into the tanks, and been treated for the purpose.

698. Would there not be danger of gravel and road drift acting as a dam at your grating?—It could not if the dredging apparatus is continually at work.

699. That is to be incessantly at work then?—It would entirely depend on experience; sometimes we might find it necessary to keep it continually working, at other times, an hour a day.

700. Is the dredging apparatus included in the estimate?—Yes, you will find an item in it.

701. What is the item that includes that?—You will find an item for "extra machinery."

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702. What is your whole item for machinery?—What machinery do you refer to?

703. The machinery necessary for lifting at the end, and for the purifying, as you say, by means of the dredging apparatus?—It is not purified by means of the dredging apparatus.

704. Separated?—It is not separated.

705. What is it then?—It is merely matters which are left behind, which should not pass into the pumps to block them; they are brought up by dredging apparatus; the dredging apparatus does not separate the particles.

706. You can give me what your estimate of the expense is?—£. 20,000 is allowed for additional machinery.

707. What does the additional machinery include?—It includes that, and other machinery.

708. Tell me what. You have not put down 20,000*l.* at random, for nothing, I suppose; tell me what is included in that item of 20,000*l.*, which you call additional machinery?—I was about to do so. It includes the dredging apparatus, and the machinery required for manufacturing the manure.

709. What machinery is that?—There are dredging machines, and extra pumps for pumping the lime into the sewage.

710. Anything more?—No.

711. You have no plans of that, as I understood you to say?—That matter is more under the next witness's cognizance.

712. Who is he?—Mr. Gibbs.

713. Do you speak to 20,000*l.* as being the correct amount of that, or no?—No.

714. Let me know what you do not speak to yourself. Do you speak to all the other items but that?—I do.

715. The engines; they are not included in the 20,000*l.*; the engines for lifting?—Decidedly not.

716. You speak to the correctness of the estimates, I suppose?—Yes.

717. And he will be able to describe to us what the mode of working them is, which you do not know?—Which I do not describe.

718. Do you know it?—It will be in Mr. Gibbs's evidence.

719. I ask one or two questions as to the tunnels; how are the tunnels to be constructed; of brick entirely?—Of brick.

720. In cement, I suppose?—Yes.

721. What thickness of brickwork for the 10-feet sewer?—Eighteen inches.

722. And what for the eight?—The same thickness.

723. And six and five the same?—The six the same too.

724. And what the five?—The five, I am not sure whether I take that at 14 or 18.

725. Have you mentioned the size of the reservoir?—It is not specified in the estimate; the quantity is.

726. What is to be the size of the reservoir on the north side?—It would take about three times the daily flow of sewage.

727. Do you mean the present daily flow?—Yes.

728. I think there is some mistake in one of your answers, as to the present daily flow; what do you state the present daily flow per minute, on the north side; it was put down as 18,000 cubic feet?—It is better than 7,000 cubic feet a minute, if the whole quantity is discharged in 16 hours.

729. You reckon 7,000 the greatest flow during any one minute?—Yes.

730. You say the reservoir is to contain, how much?—It would contain three times the present daily flow of sewage.

731. What is to be the capacity of the reservoirs?—They would contain three times the present daily flow.

732. How much is the daily flow; I will multiply by three, if you will give me that?—Seven million cubic feet on the north side.

733. These will contain 21,000,000 cubic feet?—Yes.

734. What is the space of ground that you occupy for that?—I have not got it with me.

735. What is your estimate for the purchase of the land; what is the cost of the reservoirs?—The earthwork is 6,000*l.*

736. Does that give you the quantity of excavation?—Eighty-two thousand cubic yards.

737. You

737. You can tell me what the area of that is?—I have not it with me.

738. Have you it here, that you can refer to it?—I have not.

739. What is the depth of the reservoir?—I have not the dimensions of the reservoir. The earth which is excavated forms an embankment.

Cross-examined by Mr. *Henderson*.

740. The red line on the map indicates your tunnel?—Yes.

741. Does your estimate include the expense of making communication into that tunnel of every sewer of those which the line crosses in that direction?—It includes the cost of either making a connexion with each sewer, or of connecting those sewers in some other way.

742. Does the scheme contemplate that every sewer and its contents, of which the line is traversed by your tunnel, every sewer will find its way into your tunnel?—Every one.

743. I understand you to say, your scheme is not sufficient to convey the whole of the matters passing through the sewers at all times of the year?—Not at flood times.

744. When those occasions of excess occur beyond what you desire to take for your tunnel, what means have you for stopping or checking the excess that you do not desire to receive; take some one sewer at a height of 10 or 12 feet above your tunnel, and explain to the Committee by what means you propose, first, to convey the water from the sewers above, and, secondly, how you check what you consider the excess?—We consider that the first flush of water would carry all the deposit down into our tunnel, and after some time would fill it; the shaft then being full the water would naturally flush over in its own course down into the river.

745. Take the case of any one sewer you please, 10 or 12 feet above the tunnel, I want to know the means of transmission and check between the superior sewer and the tunnel that is below it: do you make a perpendicular shaft?—No.

746. A sloping shaft?—It is a sloping curved branch.

747. From the sewer to the tunnel?—Yes.

748. The water would form a considerable weight from the sewer into the tunnel?—Yes.

749. It would be a small cataract?—No; we generally understand by cataract a broken fall of water; this would not be a broken fall, but a regular stream.

750. A fall of so many feet from the sewer to the tunnel?—Yes.

751. What length do you propose to give to that passage; how much would you diverge from a perpendicular in conveying the water from the superior sewer to the lower tunnel; take 12 feet; how long do you make the passage; the shorter the passage of course the greater the fall?—Under most arrangements of this kind, it has been contemplated to have a vertical shaft; but I consider that in 12 feet; if we went to something like 18 feet off, it would be probably sufficient.

752. To have a winding channel?—Yes.

753. Can you give what the curve would be about; supposing the depth to be 12 feet, would it with the curve be 18 feet, or thereabouts, taking the communication from the sewer above to the tunnel below?—It would be more than 18 feet; perhaps 25 or 30 feet.

754. A tortuous channel of 20 feet?—Yes.

755. Through that the fall would still be considerable?—Yes; the velocity would be accelerated.

756. What would be the width of the shaft at the entrance from the sewer into the tunnel?—It would depend entirely on the superior sewer we were intercepting or connecting.

757. Take that great sewer, the Fleet Ditch; what would be the size at the mouth there?—Sufficient to take the average flow of the sewage and rain fall.

758. I want measure; take any particular sewer, and what would you say would be the size of the mouth of the entrance from the sewer to the tunnel?—I cannot tell you in detail the particulars of each shaft.

759. Can you tell me in principle what would be about the proportion of size?—No; the proportion is not according to the size of the sewer, but to the flow of sewage in it.

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760. Take that particular sewer, which I suppose you have examined; can you give no idea of the size the passage would be?—I find that I have allowed an average size of six feet diameter.

761. By the *Committee.*] Six feet diameter to the connecting shaft?—Yes: for the curved branches.

762. By Mr. *Henderson.*] Have you a plan of the system of passage from the existing sewers to the tunnel?—Not a detailed plan; I have a diagram showing it.

763. Any particular one?—No; merely to describe the principle. It is not made to scale; it is made to convey a general idea. (*The Witness produces the same.*)

764. The shafts that I have spoken of, I mean shafts from sewers, are they in each case sufficient to convey all the contents of the sewers?—No; because the Fleet is an 18-feet sewer, whereas ours is only a 10-feet.

765. Therefore it would not convey the Fleet sewer when it is full?—No.

766. I think you said the Fleet sewer was never full; never more than a third?—It has been known on one or two occasions to be full; generally it is not one-third full.

767. What does this blue line mean; to represent the ordinary sewage?—It is merely a rough sketch.

768. You have not a plan of all these various channels of communication between the sewers and the tunnel; have you a calculation of the expense of the brickwork necessary for the purpose of all these tunnels?—I have.

769. Will you state the number of feet of brickwork that would be necessary for forming these channels of communication between the sewers and the tunnel; refer to that which states the quantity of work for the formation of that passage?—I find I have not the cubic contents here in detail.

770. Have you any computation of the number of feet of brickwork, or whatever work be necessary to form all those communications?—Yes; my estimate was formed upon that.

771. Have you a computation in your books, or elsewhere, of the number of feet?—Yes; as near as it can be ascertained, without going minutely into each particular junction.

772. Have you computed what the length and breadth of each of those passages would be?—Yes; I have taken the average, as near as I could go, without having access to the surveys.

773. You are able to decide what the size of your communication is to be, in proportion to the size of the sewer itself?—No; in proportion to the flow in the sewer.

774. You know the fall, of course?—Not in each sewer.

775. Is that part of the estimate in uncertainty?—No.

776. Can you state within 20,000*l.*, or double that sum, what the amount of making that communication would be?—I have made a statement, the same which Mr. Brassey said yesterday he was willing to do it for, whether it be more or less.

777. Mr. Brassey said the prices were sufficient, the work he left to others. I am now on the extent of the works; do you know by the number of feet, or in any way, that would enable you to compute the prices and quantity of work necessary to form that communication, by computation?—The price which I have allowed is made out by computation; it is not put down as a lump sum; neither is it a mere guess sum.

778. Apply to any one sewer, and tell me what the expense would be of making a communication from that; how have you ascertained the expense; have you calculated the number of feet, the breadth and length of them?—Taking an average length for the branches.

779. What average length have you taken?—I have averaged them 30 yards long; each junction 30 lineal yards.

780. What breadth?—Six feet diameter; that, in some cases, would probably be not quite large enough; in other cases, too large.

781. Your computation proceeds on that assumption?—Yes.

782. Your estimate includes the whole expense of forming that communication, does it?—It does.

783. Of what material do you propose to make that part of the tunnel which

which would receive the downfall of the water?—We contemplated making the invert of the tunnel the whole way of a harder description of bricks; the portion that has the scour upon it.

784. That surplus of the contents of the sewers which you cannot receive will pass on as it does now?—Yes.

785. In what way do you intercept the water, where the point is reached at which you do not wish to receive the contents of the sewer?—It passes over naturally.

786. That supposes the perpendicular passage is gorged to the top?—Yes; that it is full to the top.

787. Your notion is, the passage of communication is filled to the top, and by gravitation the water passes on?—Yes.

788. Is that consistent with the safety of the sewer, or passage, that they should be completely filled?—Quite so.

789. That 40 or 50 feet should be gorged at the top?—Yes.

790. What would be the pressure?—I have no calculation of the pressure here; but I have known culverts, under similar circumstances, to stand far greater pressure than this will ever be subjected to.

791. Are you aware that there is a pressure of 40 or 50 tons on every foot?—On every linear foot?

792. Yes?—Probably there may be; but I question whether any engineer would calculate it in that way. It is an amusing way to put it for a popular work. The pressure would not affect the tunnel at all.

793. Can you state the pressure per square inch, or in any other way?—There would be that pressure on the tunnel, but it would not act in any way calculated to endanger the works.

794. You trust entirely to the filling of the channel of communication for the passing over of the surplus water; there is no apparatus for stopping the excess?—No, not under ordinary circumstances.

795. Have you apparatus in any case for severing the excess from that which you receive?—Not excess, but for shutting off the sewage.

796. You mean at the mouth, to shut out tidal water?—No; the junction between the existing tunnel and the shaft.

797. Does that enable you at will to check whatever surplus you did not choose to receive?—Yes; but they would not be used for that purpose.

798. Would it enable you to do so?—It would.

799. At what point of the communication; what would be the apparatus by which you would check the running in of more water than what you choose to receive?—There would be the sluice, or what is termed in dockwork, penstock.

800. That would require a person present on each occasion to open it?—Yes; but they would never be used, except when we required to shut the sewage out of our tunnel for the purpose of examining it, or making a fresh junction.

801. During that time the water would go into the river?—Yes, it would pass into the river.

802. There is a vast deal of underground work to do here; have borings been taken at all the points, or any of them?—There have been a great number of borings taken by various parties.

803. Along the whole length of the ten miles?—Along the whole line.

804. At what distance from each other?—Various distances.

805. About what on the average?—About a quarter of a mile; some are nearer together than that.

806. What is the nature of the soil between this and the formation of your northern tunnel; what is the nature of the ground generally; blue clay?—Blue clay.

807. How far does that extend?—The whole length of the tunnel, with the exception of a small piece in Whitehall, where I suppose we shall find gravel.

808. Generally blue clay?—Yes.

809. The estimate you have formed of the expense, I suppose, assumes there are no difficulties arise in the ground by reason of springs or otherwise?—Yes, they are provided for.

810. How?—By pumping power.

811. What is the computation for that?—Fifteen shillings per yard run.

812. Is there no other expense attendant upon a fault in ground of that kind than pumping; any greater expense necessary in the brickwork?—Yes, it is probable we shall have to increase the brickwork at same points.

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813. It would be more expensive work through faulty ground?—Yes.

814. Besides pumping, have you made provision or allowance for any contingent expenses?—Yes, I have.

815. What?—I have allowed 20 per cent. on the brickwork, nearly a quarter; far more than we should ever require.

816. The difficulties I refer to, are those that Mr. Brunel met with in making his tunnel?—There were the same difficulties in the tunnel I was speaking of this moment, on the line of railway that I was engineer to.

817. What is the result of your tunnel being gorged; would that endanger the safety of it?—No, I consider not.

818. Should you say not?—I consider not; decidedly not.

819. What would be the consequence of the breaking of any part of the tunnel?—It is calculated that it should not break.

820. Do you say that would be impossible?—I consider it quite impossible.

821. That the tunnel could break at all?—Yes.

822. What time would it keep in repair?—It would be many years hence before it would require repair.

823. Have you ever seen brickwork subjected to that species of trial; have you ever made a tunnel yourself?—Yes, I was telling you of my experience on a tunnel.

824. What was the size of that?—For a double line of railway to pass through.

825. Was that to be subject to internal pressure?—No.

826. You have never known a case personally where the tunnel was subjected to internal pressure from water?—Yes, and under worse circumstances than this.

827. What was that?—A tunnel built on a quicksand and in made ground. I have seen there, from the air and other forces meeting together, the plates which cover the penstocks thrown some 10 or 12 feet off the ground, but the culvert is as sound now as it was the day it was put down, and I suppose will be so 100 years hence.

828. The gorging of the tunnel, I understand you to say, would not endanger the tunnel itself?—It would not hurt it at all; inexperienced people might think so.

829. If from failure of getting power, or accumulations at the end, your tunnel became completely filled, what would be the consequence to the sewer?—I can hardly suppose such a case.

830. Suppose such a case, that your lift power fails, or is not properly carried out, that there is an accumulation?—You are providing for a contingency that can I might almost say never possibly arise. You never find the engine power of the present water companies fail, and it is equally reasonable to conclude these will not.

831. Supposing the company should not be able to carry on its work for want of funds, and its power ceased in that way, what would be the effect then of completely gorging the tunnel by reason of there being no discharge at the other end; if you would rather not answer that question, I will say no more?—It is a very peculiar question; it is one that I have never given attention to; and if I thought such a possibility could arise, I would not have come forward with such a plan. If the company failed, I imagine the sewer would not be allowed to remain out of use, and all the evils arising from the pollution of the Thames to be revived.

832. I put it as a question of fact, and not as an opinion; supposing from any cause the engine is not worked, and an accumulation is at the end, what, in an engineering point of view, would be the consequence of arresting that great quantity of water in the tunnel?—Do you mean if the engine were stopped for a week?

833. Whatever the cause, assume the fact, that operations did not continue at the other end, what would be the consequence to the public of the tunnel gorging and filling?—The consequence would be, you would have the Thames in the same filthy state it is now. All those brown muddy banks you now see would be covered with manure instead of being carried away, and turned to profitable account.

834. Would it not saturate the ground around?—Decidedly not.

835. Would it not impair the security of the buildings above?—No, not in the slightest.

836. You have already explained the tunnel would convey only a certain portion of that which passes to the sewers; how much would continue to be discharged into the Thames if your system were carried into practice?—There would

would be something like 23 days in the year that the sewage would pass into the Thames. In the report issued jointly by two commissions, they state 25 days; those gentlemen I presume have taken care in going into the calculation.

837. How many square miles do you assume the sewer will take a moderate quantity of rain fall, in addition to the sewage?—It would not have to take the rain from the whole 43 square miles under the Commissioners of Sewers, as a large portion of it is suburban. We all know rain falling on a field, or the greater part of it, does not come into the sewers at all. A great portion of the urban is now without sewers, as we hear from the complaints of the inhabitants, consequently, the rain cannot come from that into the tunnel.

838. On how many square miles would the rain come in?—I calculate the urban district from 17 to 18 miles.

839. By the *Committee.*] Which is the clause that authorises you to receive payment up to 3 per cent. from the rates?—Clause 32.

840. By Mr. *Henderson.*] How is it proposed to separate the rain-fall and the sewage?—I think that is a question which I answered before.

841. How is it proposed to separate the rain-fall and sewage; have you any scheme for separating the rain-fall from the sewage; is that any part of your scheme?—No.

842. When the rain does fall, it does not fall equally?—The tables show that a good average day's rain equals about a quarter of an inch in 24 hours.

843. But it generally falls during a short portion of the 24 hours?—That would be very heavy rain indeed.

844. Does your estimate include sewage or rain-fall of any part of Greenwich, on the other side?—No, we do not carry out detailed works there; it was objected to on one occasion, when I waited on the Metropolitan Commissioners with a deputation; they expressly said that we should not carry out detailed works, as it would interfere with them. We afford the means for the locality being drained, by carrying the sewers back to our pump shaft; we have engines there to take it up; but they would not allow us to interfere with the streets.

845. You said the rain-fall comes from 17 miles of urban?—Yes.

846. The suburban you consider less?—I consider there would be but a portion come in in 24 hours from it.

847. Your scheme assumes that no rain comes from the suburban fall?—No; my scheme does not assume that; but I consider there would be nothing. My tunnel will carry off four times the ordinary flow of sewage, supposing it is divided equally over the 24 hours; that I should think allows sufficient margin for any variation, either in the water supply or rain-fall.

848. What would be the cost per annum of engine-power for lift at the further end; at the north side first?—£.75,000 is the cost price for the engine.

849. Have you any computation of the annual expense of keeping up the engine?—I have not that with me; it is a very simple calculation.

850. Do I understand your anticipation of sewage at Greenwich is not provided for by your scheme?—Yes; the means are afforded for draining Greenwich as effectual as any other part.

851. But into your tunnel it does not drain?—No; but our tunnel cuts off the upland waters from Greenwich.

852. But for Greenwich itself, the sewage is left as it was?—It is.

853. I think you said that the drainage, as distinct from sewage water, does lead to no harm?—Yes.

854. Does not the chemical matter of gasworks, the refuse, mix with it, and form part of the drainage water?—The chemical water would be taken off with the sewage, being valuable as a manure.

855. The drainage water is almost innoxious; do not chemical matters from the gasworks enter into the drainage?—No, it comes in with the sewage.

856. Do you know the proceedings of the company called the Metropolitan Sewage Company?—I do.

857. Their scheme is also to centralise or precipitate the sewage matter, is it not?—No.

858. In what respect does their plan differ from yours with respect to the use of sewage water?—They propose laying the whole country over with a system of pipes the same as water-pipes, for discharging the daily supply of water; they proposed pumping the sewage water into every man's garden and field.

859. I believe there is a gentleman of the name of Stothart has a plan similar

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to yours?—We do not bind ourselves to the adoption of any particular method for treating the sewage, but shall avail ourselves of every improvement.

860. The Sewage Manure Company you were speaking of is understood to have failed; to have been unsuccessful?—Yes, I believe so.

Cross-examined by Mr. *Webster*.

861. Be so good as to give me a plan showing Mr. Hargreave's property; what is the extent of that property?—He tells me he has about eight acres.

862. What proportion do you propose to take?—It will be a very small quantity we should require; we have not fixed definitively on any quantity; Mr. Hargreave wanted us to take the whole of it; but we do not want it.

863. You have not settled how much you will require?—No; it will not be a very large piece.

864. What works do you propose to place upon Mr. Hargreave's property?—A pumping station.

865. What will be the level of the sewer under his property?—About two feet.

866. Do you mean two feet above his property?—Below; we always measure from the water bed of the sewer.

867. How will the surface of Mr. Hargreave's property be affected by your works?—There will be a slight embankment.

868. The embankment will go quite across the property, will it not, from corner to corner?—Yes.

869. Is it a piece of property on the side of Deptford Creek?—It is.

870. Is there a portion of the Ravensbourne Sewage Works next to it?—Yes.

871. How much of the land will you require for this pumping station?—I have not any actual size here with me; it would be but a small piece.

872. I perceive that you have included in your estimate the purchase of this property?—An acre probably will be sufficient.

873. What portion of that property will you require to take?—We should take a strip through for forming the tunnel and embankment.

874. You take a strip across the property for the tunnel under the embankment, and I suppose you take a portion of it near Deptford Creek for your station?—Yes; but it is probable that the present works of the Metropolitan Commissioners would not be nearly sufficient for us.

875. I believe Mr. Hargreave has been under some notice from the Metropolitan Commissioners for some time, has he not?—He can answer that question best himself, as I have nothing to do with it.

876. Do you know this property has been a site which has been looked upon as a proper site for these works, or works of a similar kind?—It was contemplated under the Metropolitan Commissioners' scheme, I believe.

877. Do you know how they proposed to deal with this property?—No; nothing further than that they were to have a pumping station there, the same as we have.

878. You are to take a portion of the pumping station next the river, and also to place an embankment from corner to corner across the property?—Yes; but there is no reason we should follow that exact line.

879. You have a plan, or you have not; I ask you how you propose to deal with Mr. Hargreave's property; you tell me you take a portion for a pumping station, and an embankment for the covering of the sewer, from corner to corner, across the property?—Yes.

880. Where are those reservoirs to be placed that you spoke of?—In the Greenwich Marshes.

881. Is there to be any reservoir at Mr. Hargreave's property?—No; we have not decided upon that.

882. Is there or not to be any reservoirs on Mr. Hargreave's property?—I believe there was some communication between Mr. Hargreave and Mr. Morewood, one of the promoters of this Bill.

883. Has there been any communication with you upon the subject of the reservoirs upon this property?—I was going to tell you.

884. Have you any plan for reservoirs upon this property?—I have not.

885. Having no plan for reservoirs upon this property, is there anything in this Bill, or do you propose to insert anything in this Bill, to prevent your placing reservoirs upon this property?—No.

886. How much of this property do you take power to take under this Bill?—I do not know; that is a question that does not belong to my department.

887. I do

887. I do not observe any lines of deviation marked upon this; have you scheduled the whole of it; you say it is a piece of eight acres on the side of the Deptford Creek?—We have not scheduled the whole eight acres; it was merely Mr. Hargreave's wish that we should take it and pay him for it.

888. How much of this property have you taken power to take by your Bill?—Those pieces which are scheduled we should have power to take.

889. I ask you to what extent in acreage do the scheduled pieces extend?—I have not required to calculate those pieces, and consequently cannot say.

890. You have a pumping station, and you will have a pumping engine upon it?—Yes; there are some there now; it would be alongside the other; and it would be no greater expense.

891. That belongs to another establishment?—Yes.

892. Where is this manufacture that you propose to be carried on?—In the Greenwich Marshes.

893. Do you propose to introduce anything in the Bill to prevent your establishing a manufactory on Mr. Hargreave's property?—No.

894. By the *Committee.*] When were you first directed to prepare plans and estimates for this scheme?—A twelvemonth ago.

895. You say you had for some time before that considered the subject of drainage for the metropolis?—Yes, in the usual course of professional occupation.

896. Was there not a report of Messrs. Walker & Cubitt on the sewers for the City of London some few years ago?—There was, about two or three years ago.

897. Were you acquainted with that?—I have seen it; but it is within some short time; I have only seen it within the last six months.

898. Is it upon your recommendation that this sewer is limited to the size that it is now restricted to, namely, eight and ten feet at the north side of the Thames?—Yes; that carries off four times the present flow of the sewage, and I think it is quite as much as ever will be required for this area.

899. The first sewer that you take is the Victoria-street sewer, is it not?—Yes.

900. What is the size of that sewer?—It is 6 feet by 4, I believe; I am not quite sure.

901. What is the size of the Regent-street sewer?—The Regent-street sewer is a very large size; I believe it is something like 17 feet high.

902. And what width?—And about eight or nine feet wide?—I cannot carry the exact dimensions in my memory.

903. There is another large sewer comes down there, very near Charing Cross; what is that sewer?—The St. Martin's-lane.

904. What is the size of that?—I do not know.

905. That is also a large sewer?—It is a large one; the main sewer.

906. There are two sewers before you come to the Fleet Ditch, I think?—Yes.

907. Two large sewers?—Yes; those are the main sewers; the Victoria sewer first, the next the Regent-street, and then St. Martin's-lane.

908. You said one was a tunnel sewer?—It is called the Regent-street Tunnel Sewer on account of its large size; it was considered a great work when it was put in.

909. And then St. Martin's-lane?—They are at the same point; they would be near the same point, and would probably be connected by the same shaft.

910. But it is another large body of water you are to take from that large sewer?—Yes.

911. What is the next you have to St. Martin's-lane?—The Savoy.

912. What is the size of the Savoy?—It is about six or seven feet.

913. Six or seven feet high, by what?—By four or five feet wide.

914. What is the next?—The Essex-street.

915. What is the size of that?—I am not sure as to the size; it is a large sewer; those are all main sewers.

916. Is it nearly the same size as the Savoy?—Yes.

917. What is the next?—The Fleet.

918. The Fleet is also a very large sewer?—Yes; it is 18 by 12.

919. All the sewage that is brought down all these large sewers is to be taken by your sewer of 10 feet, as I understand?—As far as we have come now, it would be collected by the eight feet sewer.

920. But when you come to the Fleet, that will take in the 10 feet sewer?—Yes.

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921. But before that, the eight feet sewer is to take all that large amount of sewage?—Yes, it is the ordinary sewage; not the flood, of course.

922. Have you ascertained your sewer will be sufficient to take in all that?—I take the flow upon the northern side; the total flow.

923. Have you gauged these sewers?—No.

924. Would it not have been a more correct way to have gauged the sewers?—I have no means of doing so.

925. Can you be certain that your tunnel is large enough, unless you have had a gauging of the sewers?—I think there can be no doubt of it; the relative capacity between the ten and the eight feet is so considerable, that if the one will carry off the whole of the sewage, the eight feet will certainly carry off that from the upper portion of the area.

926. Do you say that all the sewers were made much larger than necessary, when they were made?—Many of them are not too large to carry off the storm water, but those waters we do not propose to carry off; some of them are larger than necessary; I do not know that the Regent-street tunnel sewer is ever filled; it may be; I am not aware, and I would not speak positively upon it.

927. Do I understand you to mean that the engineer who was employed in making the Regent-street tunnel sewer spent large sums of money unnecessarily in making it so large; is that so?—Yes.

928. Is that your opinion?—Yes.

929. With the other sewers in the same way, you consider that a large amount of money has been wasted in making them so large?—In many cases; where they are now really larger than the storm waters require.

930. How do you know that they are larger than what the storm waters require?—From the fact of some of them never being filled.

931. How do you know that they have never been filled, if you have never gauged them?—I get my information from various sources; there has been an immense deal published upon the subject.

932. What books have you obtained it from?—From Blue Books amongst others, and there are several.

933. What Blue Books?—From the Evidence upon the Metropolitan Sewage Manure Company, and several others.

934. What Blue Book is your last authority?—I have three here (*producing three books*).

935. They are Board of Health books, by the look of them, not Blue Books?—Yes.

936. What Blue Book have you got, which you rely upon as a good authority?—There is much to be taken from them which affects the question.

937. There is very little to be taken from the Blue Books, on which you rely as affecting your question?—Yes; but they are more for general information.

938. You have got some general information from the Blue Books, but you did not rely much on the Blue Books, if I understand?—No; I certainly did not rely solely upon them.

939. Then what did you rely upon; this Board of Health report?—Decidedly not; but upon information which I have collected from time to time from various sources; I hold in my hand the Report of the Metropolitan Sewage Manure Committee, of the 13th July 1846; the Minutes of Evidence before the Committee; it is the only report I have here to which I have referred.

940. This, which you now refer to, is a paper referred to by Mr. George Hawkins, in an Appendix to the Metropolitan Sewage Manure Report; is that part of the report, or only a report of the evidence of the witnesses?—It is the evidence of the witnesses.

941. It is a paper by Mr. George Hawkins, assistant surveyor?—Yes. That has generally been accepted as correct by all who have entered into this subject at all.

942. The Victoria-street sewer has been one of the last made, has it not?—Yes.

943. That is made six feet by four; is that larger than necessary?—I should hardly think it was.

944. Your sewer on the other side of the river is to be only six feet, to take in a much larger amount of sewage than what the Victoria-street sewer takes?—Yes; but the Victoria-street sewer takes storm waters, and everything that can possibly come into it; we only propose to take away the ordinary rain-fall; the ordinary fall of sewage.

945. The rain will equally run into your sewer until it is filled?—Yes.

946. In

946. In fact, you will have storm water until your sewer is gorged?—Yes.

947. You also said, that you expect that there will be a considerable increase of sewage hereafter, from the increase of the population of London?—Yes.

948. And that you were bound to provide for that?—I do not consider that under this scheme we should provide for any large increase; for in doubling the population, the area would double also, and it would then be time for a high level sewer to be made to take that increased area.

949. I understand you to say that you would not only drain a large urban, but a large suburban district; is not that so?—Yes.

950. As buildings increase, they will increase over that suburban district?—Yes, they will.

951. And that also will add to the amount of sewage that will come into your tunnel sewer, will it not?—It will; but the time will then have arrived for forming the upper level sewers to supply the requirements of the new district.

952. Then that map which you gave us, with one part in yellow, showing the urban district, and the other in red, showing the suburban, to be drained by your sewer, is not, in fact, to be drained by your sewer; is that so?—It will be drained by our sewer in its present condition, but not in its future. We provide for a considerable increase; for instance, there is a large portion about Stoke Newington that has no sewers, and down at Limehouse sewerage is very much required.

953. You provide for an increased amount of sewage within the urban district, but you do not contemplate providing for the increased building that may grow over the suburban district?—I do not think it is right that I should enter into the calculation; at the same time, our tunnel is sufficient to take a very considerable quantity; it will take four times the present flow, supposing the flow to pass off at a uniform rate of flow in 24 hours.

954. Can we trust your flow, seeing that you have gauged nothing?—I go by the gaugings of the Metropolitan Commissioners, and Mr. George Hawkins.

955. The drainage in the Metropolis at present is very insufficient, is it not?—It is.

956. A large portion of sewage at present is allowed to accumulate in the cesspools, and the sewage water, as it is stated, oozes through the surrounding soil?—It does.

957. When you have an improved system of sewers, that will carry off a much larger amount of sewage than is at present carried off?—Much larger.

958. Therefore, even without any additional buildings, there will be in a few years, if a better system of drainage is carried out, a larger quantity of sewage to be taken away?—Yes.

959. Then you have to provide not only for what is marked in these towns, but for the great increase that will arise from a better system of sewerage?—Yes; and as some districts become more densely populated in that portion of the area, which we have shown as urban, although at the same time there will be to set against that the depopulisation which is going on in the portion of the City, nearer the water, the houses being turned into chambers and warehouses, and the inhabitants are going westward, or into the country.

960. The urban district has increased largely?—Yes; considerably.

961. As to water supply, you have made some of your estimates from the amount of the water supply?—Yes; I feel these gaugings do give the water supply, and allowing for all other sources of water.

962. When a constant supply shall have been substituted for the intermittent supply, do you expect a large quantity of water will have to be carried off?—No, a less quantity.

963. You expect less?—Yes.

964. From what reasoning do you expect less?—From the experience of other towns.

965. You have seen the report from New York or from Boston, where they have the constant supply?—I have not.

966. From what experience are you speaking?—From what is published in the Board of Health books.

967. You believe that there will be a less flow of water after the constant supply shall have been established, than there is under the intermittent?—I should think it probable, but I have not allowed that to enter into my calculation, because I consider I have ample margin for any difference of that kind.

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968. You said something about making air-holes into the tunnels, and ventilating the shafts, as I understand; are those to open into the streets?—At present the sewers ventilate into the streets by small gratings; we should here and there have a shaft, and where it is convenient, run a pipe up the side of a building.

969. In this estimate, where is there anything for these pipes to be run up buildings to carry off the effluvia from the sewers?—We have two or three items here, which are supposed to include such contingencies.

970. Where is it; are those ventilating shafts noticed in the estimates at all?—They are not noticed in the estimates; it would be a very small amount; the shafts that we put down as forming the tunnel may remain; it is merely the cost of a few feet of pipe from that to the top of any house if the shaft once down is domed over.

971. You would have to keep there those different shafts that you speak of, for the purpose of making excavation permanent, for the purpose of ventilating; is that so?—We should not keep the whole of them; here and there one might be kept; we might, in filling them up, put a pipe down.

972. But you have not taken any estimate for that?—It is not in the estimate; it would be a small item in comparison with the whole; two or three thousand pounds would do it the whole length.

973. What led you to adopt the circular form for your sewer?—It is the strongest formed sewer that can possibly be had.

974. Are many of the London sewers perfectly circular?—No.

975. Are many of them?—I do not know that they are any of them circular. The circular form was recommended by Mr. Wicksteed, who is a man of considerable experience in these matters.

976. It was from Mr. Wicksteed's recommendation you adopted the circular form?—Not from his recommendation entirely, but because I considered myself it was the best. It includes the largest space within the smallest periphery, and we get less friction in the flow of the sewage through it.

977. You said the sewers on the south side of the Thames run upon a level, so that they could be easily changed to run the other way?—Yes.

978. I understood you to say that you had not been able to make any survey of the sewers on the south of the Thames?—It was given in evidence by a surveyor to the Metropolitan Commissioners of Sewers, that the sewers were so flat, that the men engaged in flushing them turned the sewage in whichever direction they liked, either backwards or forwards; not all, but many of them are so; the Duffield, for instance, a main sewer, is so flat, that after it has been charged by a storm, it takes four or five days before the flood water can get off.

979. I observe in your estimate, you have put down for junctions with existing sewers 5,000*l.* on the south side of the Thames; is that so?—That is Mr. Brassey's estimate.

980. No; here it is, "Mitchell"; your name at the back?—That is not my estimate; it is Mr. Brassey's; probably there is some mistake in putting them together.

981. Tell me what that estimate is?—This is Mr. Brassey's estimate.

982. This is wrong; put at the back "Mr. Mitchell"?—Yes; that is an error.

983. Have you given in your estimate?—Copies were sent to the other side; this is my estimate, although it has Mr. Brassey's name at the back of it.

984. Junction with existing sewers upon the south side you put at 13,500*l.*?—Yes.

985. As to steam-engines on the south side, you estimate the horse-power, boilers, pumps, &c. complete for 17,500*l.*?—Yes.

986. Mr. Brassey, on the other hand, puts it down on the south side, horse-power, boilers, pumps complete, 31,500*l.*; which is right?—The difference arises in this way: Mr. Brassey has a number of 450 horse-power at 70*l.* per horse; in my estimate I have only allowed for 350, which I consider sufficient, and at 50*l.* per horse power.

987. You consider 350 horse-power sufficient?—Yes.

988. And Mr. Brassey considers it would require 450?—It is a matter which he would not enter into.

989. Why then did he form his estimate upon an erroneous amount of horse-power?—I presume I must have given him that quantity some time before; he formed this estimate as much as six months back.

990. Mr. Brassey said he only knew of it first three or four months ago?—It is quite

quite six months ago ; it is probable that Mr. Brassey himself may not have known it; I was first in communication with Mr. Ogilvie, who is his managing man, and most things pass through him first; it is probable Mr. Brassey has not heard of it longer than that.

991. Then you gave to Mr. Ogilvie the amount of 450 horse-power as the steam power required for the south side?—Yes; I suppose it must have arisen in that way.

992. Do you suppose, now, that 350 horse-power would be sufficient, instead of 450?—Quite.

993. Has iron work fallen in price, so that you could do it at 50 *l.* per horse-power, instead of 70 *l.*, which you put it at a few months ago?—£. 70 *l.* was an excessive price.

994. Has it got cheaper within the last six months?—No; 70 *l.* was not a correct price for it.

995. Has not iron risen largely in the last few months?—Iron has risen, but it is going down now as rapidly as it rose; the price of iron has little to do with the cost of engines.

996. You expect to get it for 50 *l.* per horse-power?—On the quantity, I have no doubt, I should get it for 45 *l.*; there is a large quantity, and all worked off from the one set of patterns; that reduces the expense of making considerably.

997. Your plan, so far as regards the inhabitants generally of the metropolis, is the substitution of a channel, independent of the Thames, for sewer water?—It is.

998. The advantage that results is confined to that; you leave the existing system of sewers unaffected in any other way?—Oh, no; take the south side, for instance.

999. I will speak of the north first?—There are several portions of the north side which cannot be drained now at high water in consequence of the low level at which it lies; at high water the valves are shut, and the sewage is all dammed back into the sewers, and great inconvenience arises from it; when once our tunnel is made it will be drawn off continuously, and the sewers, instead of being full, and the sewage remaining quiescent for four or five hours at a time, and depositing matter which has to be removed by hand, it will, while in suspension, be carried away to our works.

1000. To what portion of the north side will that apply?—To the portion included by the green boundary upon the map.

1001. Which do you call the green boundary?—It is principally down by the docks; down by Shadwell, Poplar, and Limehouse.

1002. Then as regards the great mass of the upper side of London, it is as I described it, is it not; speaking of the north side?—On the north side it is more particularly of benefit in purifying the Thames.

1003. In that way do you contemplate they are to be benefited by purifying the Thames; that is to say, to what extent is it to be purified, in order that they should get that benefit?—There is another benefit which we offer; that is, that any fresh branch, or lower level branch, that is required, can be brought into our sewer.

1004. Your rate is to be indiscriminate; you are not to make any distinction, and to levy the rate on those who may require the special benefit, but it is to be a rate upon the whole district that is comprehended in the limit that you have assigned?—I think it is in the Bill according to the benefit derived.

Mr. *Hodges* stated it was proposed to leave it in the hands of the Commissioners of Sewers to state in what districts the rate should be raised.

1005. To what extent do you consider, leaving out of consideration those particular districts which by virtue of the lower level of your tunnel, will have facility for carrying off the sewage water, benefit will result to a vast portion of the northern side of London, from the Thames being purified, and what extent of purification do you contemplate when you imagine that they will get that benefit: that is, to what purpose is the Thames to be applied after it is purified, so that the inhabitants should get the advantage?—There are more benefits than would result from the purification of the Thames; in the first place, we must look at it almost as a national thing; it is the highway for the commerce of the kingdom; by purifying the lower portion it would preserve the upper from being polluted as well; the sewage is now driven back into the country, and those companies which take their water supply from there would be benefited.

1006. Is it with a view to the metropolis being supplied with water from the

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1007. With respect to the purification that may result; if you contemplate water being drawn from the Thames, you must contemplate the Thames being rendered more pure than it is now at all times, must you not, in order that you should look upon it as a source from which water companies are to draw their supply?—It should be certainly pure at all times.

1008. Now take a storm occurring suddenly, how soon do you imagine a passage from the existing sewers into your drain will be choked; describe generally what will be the operation of choking the communication, and how it will occur?—The daily flow, as I before stated, upon the north side, is better than seven million cubit feet a day; our tunnel will hold just upon four million cubic feet.

1009. Do you contemplate that your whole tunnel will be filled from end to end before the excess from the different sewers is checked?—Yes.

1010. Do you contemplate, before any one of the passages from the existing sewers is choked, that your whole tunnel must be choked from end to end?—That it must be full.

1011. That is your view?—Yes.

1012. Will not the rush of water be very much more rapid down this channel from the main sewer than the passage of the water at a distance from that in your tunnel?—The velocity of the water down the curved branches will be greater than in the tunnel.

1013. And do you not imagine that that rush of water through a channel nearly equal in capacity, as you have described this passage to be, to the amount of the tunnel, will cause a choking of your tunnel at a short distance from the entrance into it before the whole of your tunnel is filled?—No.

1014. Do you imagine the progress of the water will be equally rapid at a distance from that descent, and immediately in contact with it?—The branches would be carried in as near as possible in the line of the sewer, so as to preserve the same line of flow.

1015. You have first communication with the Victoria-street sewer that runs in and communicates with you at the end?—Yes.

1016. Assuming that was coming down with a full flush of water; then assume the other communications that you have spoken of, with the large sewer at Regent-street, and the other; do you imagine that the flow of water through the channels from those large sewers into your tunnel at those several places would not cause a choking of the water until the whole of that water had found its way ten miles off, and through a channel the fall of which is only four feet in a mile?—If I understand the question right, it is, would not that fill the tunnel in its passage?

1017. The question is, whether from the rapidity with which it came down channels equal in capacity to your own tunnel, or nearly so, would the flush of water in the several sewers cause a choking at this end of the tunnel before the other end was filled?—No, I think not; probably you have misunderstood one part of my evidence. I have allowed in my estimate for branches of six feet in diameter, but that is to cover any possible expense; I have taken the outside cost; we should not have branches of that size in each case.

1018. Then if you diminish your branch, the branch would not be able to carry the whole water down, and a large portion of it would at once flow over to the river by its own course?—Yes; but the storm waters do not now come down full bore at once; they rise by degrees.

1019. You have already said, you do not know to what extent those sewers are filled on a sudden flush of water?—I know by general experience in such things, that they never are filled immediately, pipes or drains.

1020. Do you entertain any doubt that in a sudden fall of water, that a very large portion of the water would pass over into the Thames by the present means of communication?—There is no doubt but that a large portion would.

1021. Why do you assume that the water would not be foul water?—Because the first flush of water coming down would scour out the sewers.

1022. Have you ever observed the water pouring down the streets that could not get down the existing communications with the sewers below?—Yes, and it is certainly very turbid.

1023. Would not also all the sewage water, or a very large portion of it, when it

it got into the channel, the other being choked, be carried over the mouth of the branch communication, and so down into the Thames?—I consider that the sewage deposit would be among that which passed into the tunnel first; the sewage which would be discharged from the houses during the time of the flood would, of course, pass out with the flood waters.

1024. Into the Thames?—Into the Thames.

1025. With regard to the south side; there is a very large portion, as it appears by that map, and a densely populated portion of the south side, that lies between the river and your tunnel; is there not?—There is.

1026. And a great number of public works?—Yes; between the main tunnel and the river.

1027. The impurities which on such an occasion would find their way into the Thames from the south side would be very considerable at the period of a sudden flush of water, would it not?—No; they would be brought back by the branches.

1028. You say they are nearly at a level now; you do not mean to say that they are so formed as to run backward at present?—No.

1029. Assume that they are nearly level, at a period of sudden flush, would not a great quantity of that go to the Thames, as it does now?—There would be some portion of it; but the storing capabilities of the sewers on the south side are very large; beyond that it would exactly proceed in the same way as on the north side. The line you see on the map does not include the whole of the ground or works and sewers which we put in; we have another branch, which collects the sewage of so much of the tunnel as is not intercepted by that, or so much as remains between that and the river.

1030. How do you mean you have another; where in your Bill are you bound to take any steps for preventing the sewage lying between either the one tunnel or the other from finding its way into the river.

Mr. *Hodges* stated there was no clause in the Bill obliging the promoters to make a communication with those sewers, but there would be no objection to a clause making it compulsory.

1031. In putting in those drains on the south side that you speak of, you may want to deal with the property of individuals other than the public streets, may you not?—In one or two small pieces of ground.

1032. How do you propose to do that; do you propose to do it in any cases where you have not scheduled the property?—No; the property is all scheduled.

1033. Do you not take a power to deal with the property, whether public or private, in putting in these branch communications?—The property is all scheduled.

1034. You do not contemplate taking any property that is not scheduled?—No; and we do not wish for the power.

1035. Do you contemplate a deposit of hard material at the junction of these curved channels with your tunnel?—We bring them on in the curved form I spoke of, to prevent that.

1036. Bring them in as you may, they are in some measure diverted from the straight course of the channel?—Yes; but not so as to cause an accumulation at their junctions.

1037. And it will come down with a greater velocity than the velocity at which a body would be moving in the ordinary part of the channel, will it not?—The velocity of the water in the branches would be greater than that in the main line; when I say branches, I mean in the junctions.

1038. And therefore all hard matter coming down the branches would be precipitated into the tunnel at a greater velocity than the velocity of a body moving in the ordinary channel of the tunnel?—Yes.

1039. The ordinary velocity of your tunnel you contemplated would be about three miles an hour?—It is under three miles an hour.

1040. With so sluggish a channel as that, do you not contemplate there will be formed deposit at the mouth, or at a short distance from the mouth, of this, of hard material, tending to check the water there?—No; that is considered sufficient to carry pebbles along with it.

1041. Three miles an hour?—Yes. The evidence of Mr. Phillips, the surveyor of the Metropolitan Commissioners, goes to prove 150 feet a minute is sufficient to keep a sewer free of deposit. Our velocity is greater than that. Some of the oldest authorities, Smeeton and others, have gone into the same sub-

Mr. *J. J. Mitchell.* ject, and they make it two miles and a half an hour is sufficient to remove the stones and all loose materials.

7 June 1853. 1042. You stated you could not apprehend any possible danger in this scheme at any time, if the tunnel were choked; are you not aware instances have happened in which these different sewers have burst?—That has arisen from their being either near the surface or from imperfect construction.

1043. Do you recollect, about four years ago, a sewer bursting in the Green Park?—No, I do not.

1044. You are not aware of that?—No.

1045. Will not the effect of this tunnel depend very much on the season; in a dry season surely you will have a very large deposit in this tunnel, and a large mass which will not be moved?—No.

1046. Will there always be water coming in from the different sewers?—Yes; because the greater portion of the water is derived from the water supply, and that is known to be greater in summer than in winter.

1047. As to the ground about Barking, what is the nature of the ground where you propose to have this reservoir?—For about 20 feet down it is peat earth; it is not a good soil, but there will be no difficulty in forming a reservoir.

1048. You cannot mention the exact size of the reservoir?—No; I can supply you with it.

1049. How do you propose to dry this?—It is done by a series of bands in hot air.

1050. How long would it be in the process of drying?—The whole process occupies a couple of hours.

1051. Are the reservoirs to be covered?—Yes.

1052. In what way?—These reservoirs, which I have allowed for in my estimate, are of a different construction from those which we shall adopt; but the next witness will show you that the sum is sufficient to cover the expense of them.

1053. And to cover the reservoirs?—Yes; they would be covered too; it is one part of the scheme to take the gas which rises and purify it.

Re-examined by Mr. *Hodges.*

1054. You have been asked questions as to your experience; you are the son of a civil engineer?—I am.

1055. From a very early period of your life have you been actively engaged in matters relating to that business?—From the earliest days of my life.

1056. Your father executed some very difficult and important works at Deptford for the Government?—At Sheerness, those were the principal works.

1057. Did you assist him through all those works?—No; not through the whole of them. They were commenced many years since.

1058. All your time has been devoted to matters relating to your profession?—Quite so.

1059. With reference to the large size of existing sewers, take the case of the Victoria-street sewer and other large sewers you have described; those sewers are calculated to carry this surplus rain as well as the ordinary sewage, I believe?—They are.

1060. They are calculated to carry off the greatest possible storm?—Yes.

1061. Is it not the fact that the power of the sewer to discharge the water depends on its fall as well as upon its size?—It does.

1062. Therefore, if you have a sewer to discharge water when the fall is not good, it would require a larger sewer than if you had a good fall?—Yes, it would.

1063. As to the sewer you propose, we have heard the rate at which the water would travel along its course; would not that be rather a rapid stream?—Yes.

1064. It would not be at all a sluggish stream, would it?—No.

1065. You have often observed water travelling at that rate; it is rapid, is it not?—It is sufficient to remove any deposit of stones, or anything which may fall in.

1066. Now with regard to the gauging for the purpose of ascertaining the present delivery at the sewer's mouth, have you before you a report lately made by the London Commissioners of Sewers?—Yes.

1067. Have you read that report?—I have looked through it.

1068. That is very recently published, I believe?—Within the last week or two.

1069. A report on this very scheme; and they have also come to a conclusion as to what the quantity delivered from the sewers is on the north and south side: refer to that passage?—Yes, I have. It is this: "A Report to the Commissioners of the Metropolitan Sewers and the Commissioners of Sewers of the City of London, on the scheme of the Great London Drainage Company, by Mr. Bazalzette and Mr. William Haywood."

1070. The quantity they mention is something larger than the quantity you have mentioned?—It is.

1071. What do they make the quantity there?—On the north 9,100,000 cubic feet.

1072. That is somewhat more than you made it?—Yes; we have taken it at about seven millions, or seven millions and a half.

1073. If you turn to one of the pages that is marked, you will find the south side mentioned?—At page 19.

1074. What do they make the discharge there on the south side?—They give it as three million cubic feet per diem.

1075. You made it two millions and a half?—Yes.

1076. Therefore altogether it only exceeds you by two millions, if you put the two together?—That is all.

1077. I believe you took considerable trouble to arrive at a conclusion as to the true quantity of water discharged into the sewers before you brought forward your plan?—Yes.

1078. I ask you, whether the tunnel you propose will carry off the amount at which the City Commissioners have put it?—It would carry off four times that amount.

1079. Four times?—Not quite four times; very nearly four times the quantity.

1080. Therefore, to discharge the quantity mentioned by the Commissioners of Sewers, your tunnel would not be much more than half full?—It would not be half full.

1081. It would not be one-third full, would it?—It would be about one-third full.

1082. Do you consider that you have therefore made ample provision for carrying the ordinary sewage of London, including ordinary rain?—Ample.

1083. Do you think it would be a defect in your scheme if you had your tunnel larger than that which you propose?—I think so; I consider that our tunnel is quite sufficient, taking either the quantity which we have, or the quantity allowed by these gentlemen.

1084. Would it also provide for the circumstance that there may be a larger quantity delivered at one hour of the day than another?—The experience at Wolverhampton, for instance, proves that the water supplied by the water companies is drawn off much more rapidly at one time of the day than another, but that would not reach the sewers at the same rate; for instance, taking their numbers as representing the hours at which it is drawn off in London, and we find between the hours of three and four in the afternoon the largest quantity is drawn off; that is drawn off equally over the whole area; the portion drawn off on the lower part would have passed off, before that from the higher part came down to the tunnel.

1085. Therefore the sewer would be ample for the discharge at any time of the day in ordinary cases?—Quite so.

1086. Have you seen the city surveyor, Mr. Haywood, on the subject of the size of your tunnel?—Yes.

1087. Have you had conversation with him?—Yes.

1088. Has he expressed any opinion on the size of it, for carrying off ordinary sewage?—He considered it ample.

1089. If provision were made for carrying off these excessive rains, which happen 23 or 24 times in the year, do you think that would be a good scheme?—No, decidedly not.

1090. The expense would be enormous?—The expense would be enormous, and the ordinary flow would not be so effectual through a large tunnel, as through a small.

1091. Some difficulties might arise in making a much larger tunnel through the heart of the City, might there not?—Undoubtedly the risk would be greater in a larger one.

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1092. You consider, under all the circumstances, yours is the best plan of the two?—I do.

1093. Have you very maturely considered that part of the case?—I have.

1094. You have been asked whether sewers are liable to suffer in case they become choked from pressure; do you happen to recollect the Thames Tunnel in the course of its construction; was not that filled with water for some time?—Yes.

1095. The pressure was very great?—Yes, and it was filled very suddenly.

1096. Was any injury done to the work?—There is not any recorded, and I have had considerable conversation with engineers engaged upon the works.

1097. By the *Committee.*] What was the thickness of the Thames Tunnel?—I am not sure what the thickness was, but the diameter is very considerable, and the Thames Tunnel is subjected to far more trying circumstances.

1098. By Mr. *Hodges.*] Do you think an occurrence is likely to happen to a tunnel constructed as you propose to construct it, that from pressure it would burst?—No.

1099. It was suggested to you the pumps may stop from some cause or another, and the scheme be abandoned; there would be nothing easier than to renew the present communication, would there, into the present existing sewers, so as to use the Thames at all times?—It is merely a matter of shutting down the pen stocks.

1100. And then the sewage would flow into the Thames as now?—Yes.

1101. That can be done at any time?—Yes; we do not propose to interfere with the present outlets.

1102. Do you anticipate the slightest difficulty in effecting communication with the river in the manner you have mentioned?—Not any.

1103. You think as soon as your tunnel is full the water will flow through quite as conveniently as it does now?—Yes.

1104. With regard to the benefits which would arise from clearing the River Thames from these impurities, do you think it would be very beneficial to the health of the inhabitants?—Undoubtedly. Cholera is found to have prevailed along the banks of the river, especially where the sewers were discharged.

1105. Is there not a great accumulation of putrid matter on these muddy banks we hear of?—Yes, the brown portion on that plan (*referring to a plan on the wall*); at Waterloo Bridge you see half of the river at low water is exposed, and in front of Whitehall I have seen it myself almost red with animalculæ on the surface of the mud.

1106. Perhaps you have seen the state of the bank in a boat?—Yes, it is very bad.

1107. That is an evil likely to increase?—Yes.

1108. You also say the effect of your plan would be to have a constant flow through this tunnel sewer without intermission at all times?—At all times.

1109. At present that is not so with the existing sewage, is it?—No; 16 hours out of 24 the sewers cannot act; the sewage is now dammed up under the streets; the sewers become long cesspools under the streets.

1110. And the foul air comes up through the grating?—It does; as the sewage passes out, the sewers of course fill with air, that being contaminated with the deposit in them; again, the sewage flows in from the houses, and not being able to get out in consequence of high water, it forces these gases through the drains and gratings into the houses.

1111. You have been asked with regard to the increase of population; do you not think this would provide for sufficient sewage for a very great number of years, including the increased population?—There is the margin of four times as much as the present flow.

1112. Do you see any immediate prospect of such an increase as would induce you to recommend a larger sewer than that you propose?—Not any.

1113. And if the necessity should ever arise, would it not be very easy, by expending further money, to carry out your plan, and to have it complete for any new population that may spring up?—Do you speak of either side in particular?

1114. The north side?—I consider that if the north side should become double, as is spoken of in this Report (*referring to the Report of Mr. Bazalzette and Mr. Haywood*), that then it would not be judicious to depend entirely on a sewer by the side of the river, but a new one should be provided round the present area to collect the sewage from the new area that would be built upon.

1115. A question was put to you with regard to Greenwich; you say you have not provided for the draining of Greenwich; would the works of the company be such

such as could be used beneficially by the inhabitants of Greenwich, if they so pleased?—It would afford a constant outfall.

1116. Which they could make use of?—Yes, that they could make use of at all times.

1117. They might make a sewer emptying itself into the tunnel?—They might drain the whole of Greenwich, and the whole of Deptford. Deptford would drain into the low level sewer, and Greenwich would drain back into our pump shaft.

1118. Would the capacity of your sewer be sufficient to receive that?—Yes.

Mr. *Alexander Ogilvie* Examined by Mr. *Calvert.*

1119. I BELIEVE you are a Civil Engineer?—Yes, and Contractor.

1120. You are in the habit of acting confidentially with Mr. Brassey in his principal works?—Yes.

1121. Have you prepared the estimate in respect of the work now before the Committee?—Yes, I have.

1122. With all the details?—I have.

1123. Has that been prepared with a view to the entering into a contract for the purpose of making them?—It has.

1124. Have these details been generally looked at by Mr. Brassey?—They have.

1125. Is that for the purpose of his adopting them for the basis of his contract?—Yes.

1126. Have you been engaged in company with Mr. Brassey on the footing of your making out estimates of this kind for many years?—For 13 years.

1127. You have spent some time, have you not, in the examination of the details of the London drainage?—About eight or nine months.

1128. Have you investigated all the plans, and met with the engineer of the company, for the purpose of investigating them?—The plans and sections.

1129. I believe Mr. Brassey produced an estimate for the north side of 658,376 *l.*, and for the south side 349,877 *l.*?—Yes.

1130. Making a total of 1,008,253 *l.*?—Yes.

1131. Were those estimates prepared by you?—Yes.

1132. Were they prepared on a full examination of all the details of them?—Yes.

1133. I believe you have had great experience, not only in making estimates, but in the examination of works of this description; tell me whether, in point of thickness of masonry, you think these works are adapted to the purpose for which they are intended?—I think so, fully.

1134. Should you, from your experience, say that they are works which may be executed with a perfect certainty of their success?—Yes.

1135. Do you think that the work can be executed for the sum which has been mentioned?—Yes, I think so.

1136. Can it be executed for less, do you think?—I dare say other people would be inclined to execute it for less, but when I execute works, I should like to have a profit in making those works.

1137. In short, those works may be well done, and a fair profit will be left to the person who does them, and you think your estimate is sufficient for that?—Yes.

Cross-examined by Mr. *Henderson.*

1138. You yourself examined the ground, did you, with reference to this estimate?—Not the whole of the ground; the plans and calculations for the size of each tunnel.

1139. Did you yourself calculate or ascertain the size of communication that would be necessary for the communication with the tunnels?—No; there is a large amount put down in the estimate of that, which I think is very ample.

1140. You have not examined them?—I am quite willing to undertake that work for this amount.

1141. You trust to the accuracy of those who have furnished you the materials for it?—Yes; and for the additional 50,000 *l.* I would run all risk about it.

1142. I am not questioning you about your plans, or the propriety of your plans; can you tell me anything about the quantity of work yourself; do you know on that particular part of the work the quantity of brickwork and connexion

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that would be necessary to form the communication between the sewers and the tunnel: have you verified the fact, or examined it?—The quantity of work that would be necessary?

1143. Yes, to form the communication between the sewers and the tunnel?—Not every communication; I have verified some of them, but not all.

1144. How many sewers are there communicating?—That I do not know; I do not profess to have any knowledge about the number of sewers in the City.

1145. Do you know the nature of the ground?—I have been furnished with borings, and from the nature of the borings I have been furnished with, I have no hesitation in saying my estimate is fully ample.

1146. Assuming the quantity of work to be what is represented to you, you would undertake it at that rate?—Certainly.

1147. The quantity of work you took from the statement made to you?—Yes.

Cross-examined by Mr. *Clerk.*

1148. Were you provided with any working plans?—I was provided with a plan.

1149. Showing the main tunnels?—Yes.

1150. Did those plans with which you were provided show more than the main tunnels on either side of the river?—On the south side they showed more than the main tunnel.

1151. What more did they show?—They showed the connecting branches.

1152. You have told my friend none of the connexions or number of connexions were stated to you upon the plans?—No, not the number of connexions.

1153. Nor the extent of the works on each connexion?—Except those you see on the south side.

1154. I understand you to say that this has been prepared as the basis of your contracts; do I understand that you are prepared, or that you are bound to take that contract?—I think so.

1155. You say the estimate has been prepared as the basis of a contract; do I understand that either you or Mr. Brassey are prepared to enter into this contract?—Yes; Mr. Brassey stated in this room, for 50,000 *l.* additional he would enter into it, and I am quite prepared to do the same.

1156. I thought I understood Mr. Brassey to say he did not feel himself bound without mature consideration to enter into a contract at all, and if he took it at all, it would be with an addition of 50,000*l.*?—That was to cover contingencies; here are his own figures put down on it for contingencies.

1157. I understood Mr. Brassey to say, without mature consideration he would not be prepared to enter into a contract, even with the addition of 50,000*l.*; was not that so?—I did not hear him say so.

1158. Are the reservoirs which are to be constructed and the passage of the tunnels estimated for?—Yes.

1159. What is the area of reservoir for which your estimate is formed?—I have not got the area; I have only the cubic contents of earthworks; I have not gone into the area.

1160. There must be a certain amount of brickwork, and other details in the construction of the reservoir, which must be included in the estimate?—Yes; I have 360,000 cubic yards of earthwork to form a reservoir on the north side at 1 *s.* 6*d.*; concrete, 44,000 cubic yards at 6 *s.*; York paving, 5,500 super yards at 7 *s.* 6 *d.*

1161. I do not want the details; what I want to ascertain is this; whether you were informed more than that there would be a certain quantity of earthwork to be done, or whether you were told what would be the capacity of the reservoir?—I was told there was a certain quantity of work to be done in the reservoirs.

1162. You were not informed what the capacities of the reservoirs were to be, or what their area was to be?—Not what their area would be.

1163. How can you ascertain the capacity without knowing the area?—You must know the area first.

1164. You are not aware of what the capacities of those reservoirs are to be?—I am not.

1165. Are those reservoirs to be covered?—No; they are not allowed for covering in my estimate.

1166. Have you considered at all, supposing the northern reservoir to cover an area of 36 acres, what the expense of that would be?—I have not.

1167. Can

1167. Can you give the Committee any proximate idea of what the expense would be?—Not at the present moment, I cannot.

1168. It was not mentioned to you as a matter to be considered in your estimate, whether the reservoirs were to be covered or not?—No; it is not in my estimate; the price that is for the reservoirs is very ample; that is probably more than double what would be necessary for the work; that is, the 1 *s.* 6*d.* would be double what was required; I should think in all probability the work would be done for 1 *s.*

1169. The price given is a liberal price for the amount of earthwork that was stated to you?—Yes; but I beg to say I have 10 per cent. in the whole in addition to this afterwards. There is 90,000 *l.* in addition to all these prices, taking the two sides; 10 per cent. on the whole amount.

1170. By the *Committee.*] In addition to the 50,000 *l.*?—Yes; that is before the 50,000 *l.*; there would be sure to be some additional works required; that would come in.

1171. By Mr. *Clerk.*] You are not aware of the details of the engines; how have you estimated as regards the engines?—The north side 1,250 horse power, 70 *l.* per horse power, about 87,500 *l.*

1172. Are those single or double engines?—Divide them into four or five engines; you would never have that power in one engine.

1173. We heard something of a dredging machine to be constantly kept at work; is that allowed for in the estimate?—No; but I think there is more than sufficient to cover that in the engine power. If I had an order for engines to-morrow, I could get them for 40 *l.* a horse power; certainly under 50 *l.*

1174. By the *Committee.*] Why in the estimate was it put down 70 *l.*?—This is to allow a margin for anything which may occur.

1175. By Mr. *Clerk.*] When was the estimate prepared?—This estimate was prepared, I think, in November or December last.

1176. Has not the price of iron risen since November?—It is going back.

1177. The price of iron is now higher than it was when you formed your estimate?—I think not; I think rather lower. We have been able to purchase rails at less money.

1178. Than you could in November?—I think so; I am not positive to the month.

Re-examined by Mr. *Calvert.*

1179. Tell me, these things you have not absolutely done with your own hands, have they been done by persons whom you are in the habit of employing for that purpose?—Yes, by my assistants; they have been gone into very minutely.

1180. Persons usually employed?—Yes.

1181. Will you explain to the Committee on what principle you have calculated the communication between the existing sewers and the proposed tunnel; I presume, of course, you had no means of going down for the purpose of examining the ground; in the first place, you knew the geological strata?—Yes, as far as it is possible to ascertain it.

1182. Upon what principle have you calculated the expense of making that communication?—We took the pen stocks, iron-doors, and ironwork altogether, and put down a certain amount for the whole.

1183. The length of communication, how have you calculated that?—I have taken that off the plan.

1184. You know the position of the existing sewers, and you know the position of the tunnel?—Yes.

1185. And therefore you know the length?—Yes.

1186. And you know as accurately as science will give it the geological formation?—Yes.

1187. And then upon that data have you taken a rough sum which you think will cover the actual expense?—Yes.

1188. Had you any other data than that I have mentioned on which to found yourself in that calculation?—No.

1189. With regard to the reservoirs, I presume you were told the quantity of brickwork that would be required to obtain the capacity which was necessary for the works, and you put your calculation upon that brickwork?—Upon the earthwork chiefly.

1190. That is the usual way in which it is done, is it not?—Yes.

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Examined by the *Committee.*

1191. You say you know the geological formation through which the tunnel will pass?—Yes.

1192. In the north tunnel, what extent is there of ground through which the tunnel would pass which is other than clay?—I do not think there were above 300 or 400 yards other than clay, except it might be a little of that towards Barking Creek.

1193. What is that 300 or 400 yards?—Gravel. We do meet with a pot-hole of gravel in clay, but I do not think there will be much of that, and that I have allowed for, expecting that.

1194. Where is that 300 or 400 yards of gravel?—I think we shall find it adjoining the Victoria Sewer.

1195. Does the meeting with gravel add much to the expense of the tunnel?—It adds something to the expense, if there is much water in it; there is the pumping; that it is that adds to the expense.

1196. How many shafts do you think it likely, in a densely populated part of the town, in working your tunnel, according to your calculation, you would require?—I have calculated six to a mile; but that must depend a little on the public convenience, and also where they could be obtained.

1197. Do you contemplate as many as six to a mile where you are, in a densely populated part?—I have allowed for six to a mile, and I think it could be done with four or three to a mile through the north side, and rather under seven on the south side.

1198. Do you think that the tunnel ought to be ventilated?—I can hardly speak as to that, whether it really ought to be ventilated or not.

1199. You are not aware whether or not it is necessary to ventilate it?—It would not be necessary unless there was a quantity of air forced into it, to take the air out again. If it were, there would have to be an upcast shaft, as it is called in collieries, to take that air off.

1200. Certain ventilation would result from the existing branch communications with the existing sewers?—Yes; I should think that would be quite ample in all usual cases; it might not be desirable to have more ventilating shafts than really were required.

1201. Should you like to go through that tunnel with no other ventilation than that which will result from the branch communications; that is in point of fact safety; would it be safe for the men?—I am not prepared to answer that question.

1202. Have you ever been employed at all in the construction of sewers upon a large scale?—In tunnels, but not sewers particularly; in tunnels of all sizes.

1203. What is the largest tunnel you ever made in a railway?—About 25 feet in width and about 25 feet in height; then there is an invert underneath; that is three or four feet.

1204. Are the tunnels you have made always circular?—No; they are very much more difficult to make in consequence of their not being circular; we are obliged to make strong side walls, nearly upright, so as to give sufficient space for the trains; a circular tunnel would be much larger to allow two lines of rails to run through.

1205. Do I understand making the tunnel perfectly circular would be much cheaper than if made in any other shape?—I think so; I think it is cheaper and stronger.

1206. By Mr. *Calvert.*] Would it be better in that shape than any other; whether under heavy embankments you would prefer a circular culvert to any other shape?—Certainly, circular; I have had the egg-shape crushed time after time, and been obliged to make it circular afterwards.

1207. Your experience is that the circular will succeed?—It is my experience that circular is the best shape for strength.

1208. By the *Committee.*] For the purpose of securing a constant and equable flow of water, which is the best shape?—That I have not considered.

1209. By Mr. *Calvert.*] In a work of this description, do you prefer the circular to the egg-shape?—Most decidedly.

Mr. *Joseph Gibbs* called; Examined by Mr. *Calvert*.

1210. ARE you a Civil Engineer?—I am.

1211. I believe you have been much connected with the subject of hydraulics?—Yes, extensively.

1212. And with the lifting of water from low levels?—Yes; I have had considerable experience in draining situations like this district now proposed to be drained, and where the surface of the ground has been too low for a natural outfall.

1213. I believe you have recently been engaged in a work of great interest at the Lake of Haarlaem?—Yes.

1214. Is that a work requiring the application of hydraulic principles, under very difficult circumstances?—Very difficult; because one part of it is 13 feet under the level of the tide.

1215. You have altogether, I believe, had about 30 years of experience in hydraulic questions?—Yes.

1216. You have been consulted for some time by the promoters of this scheme?—Yes; I have been consulted by Mr. Brassey and his partner relative to the undertaking, and the details have been put before me about four months, I think, but I am not certain as to the exact time.

1217. Have you gone into all the different questions connected with this work?—Yes, I have.

1218. The situation, its cost, and its hydraulic character?—Yes, I have attended to all those details.

1219. The geological character of the ground through which it is to be made?—Yes.

1220. Take one subject first; take the question of the rain-fall; you have examined the several basins through which the rain-fall round London passes through to the Thames?—Yes; I have known all these basins for 20 years intimately; I have since examined them also with a view to this question.

1221. Have you a map there explaining the different water-sheds?—Yes.

1222. Will you point out the various water-sheds upon the northern side?—(*The Witness exhibits the plan to the Committee and explains.*) Those are the water-sheds belonging to the basins within the district of this proposed work.

1223. Those different water-sheds are marked with the numbers 10, 1, 2, 3, 4, 5, 6, 7, and 8?—Yes.

1224. Upon the north side?—Yes.

1225. Upon the south side they are marked with the letters D, C, and B?—Yes.

1226. With regard to the different districts, which of them are districts in which the rain-fall passing down them will flow into the Thames without coming into any of the sewers that communicate with the tunnel?—No. 1, or Walbrook district; No. 2, or the Fleet district; No. 3, or the Westminster district; and D. upon the south side, or Black-ditch district; and C, the River Effra district.

1227. Will the rain-fall from this district pass into the sewers communicating with the tunnel or not?—Yes, it will under ordinary circumstances.

1228. Now, with regard to the remainder of those districts which are marked with those numbers and letters, will the rain-fall pass into the Thames, and not into the sewers?—Yes.

1229. Passing into the Thames without going into the sewers at any time?—The districts Nos. 4, 5, 6, 7, and 8, will go into the Thames by the ordinary channels which now exist, and are not influenced by the works now proposed.

1230. But will your tunnel sewer take the sewage of Nos. 4, 5, and 6?—I cannot undertake to say it will, because I do not know how far the Victoria Sewer is driven up; but if that sewer is continued, it will take it until the tunnel is surcharged, and can carry no more.

1231. By Mr. *Calvert*.] What is the whole of the area of the rain-fall, which you have numbered and lettered in this way. Is the whole area 425,117, or 66½ square miles?—Yes.

1232. The city surveyors, state in their publication, which the Committee have before them, the water-shed is 47 square miles upon the north side?—I have so read it.

1233. I believe they do not state the number of square miles upon the south side?—No; there is no reference to it.

1234. What quantity of the total area on the north side will be the water-shed from

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from which water will go into the tunnel; how many acres; the acres of 1, 2, and 3?—One hundred and thirty-eight thousand and seventy-five cubic feet; but that includes a considerable quantity of absorbent ground, which, of course, forms springs by absorbing the rain-fall, and by that means regulates the rain-fall.

1235. One hundred and thirty-eight thousand and seventy-five acres is 21 and two-thirds square miles?—Yes.

1236. About one-half the area suggested by the city surveyors, as pouring water into the drains?—Yes; but I apprehend the city surveyors alluded to the separate water-sheds which I have enumerated before, and which would not at all be affected by this question.

1237. I believe the suggestion of the city surveyors is, that a quarter of an inch of water falling within 24 hours must be provided for?—That is the suggestion; but I think a larger quantity than that ought to be calculated upon.

1238. The area includes 1, 2, and 3; does it not?—Yes.

1239. What is the quantity of water flowing from 1, 2, and 3, which would be given by the quarter of an inch falling in 24 hours?—Eighty-seven thousand and forty-four cubic feet per minute.

1240. Would that be the increase of the flow down the tunnel during every minute of the 24 hours?—Yes.

1241. That gives 12,591,000 cubic feet in the 24 hours?—Yes.

1242. Is the tunnel amply capacious for that purpose?—Yes.

1243. What is the capacity of the sewer equal to per minute; 20,000 feet, is it not?—Yes; 20,000 feet; but still I would wish to speak cautiously upon that point; there are bends in it, from which I must make deductions; I should not like to give much beyond 15,000, although those bends may be made to work without damming up the water to any very great extent.

1244. I believe you have ascertained that the usual flow would be 4,861 feet?—Yes.

1245. Then to ascertain what will be the flow on the quantity of waterfall at a quarter of an inch per minute, we must add the 87,044 cubic feet?—Yes.

1246. And that will give 13,605 feet under the most difficult circumstances?—Yes.

1247. Is not that upon the supposition that the entire rain-fall passes into the sewer?—The quarter of an inch; not the entire rain-fall.

1248. Would it be the case that the entire rain-fall will pass into the sewer, or will any part be absorbed?—No; the sewer would be filled long before the entire rain-fall arrived at its maximum.

1249. Admitting for that difference, what would be the difference in the quantity of 87,044; to what should you reduce it; what will be the proportion of those 21 and two-thirds square miles to the absorbent?—It is difficult upon a varying soil of this description to ascertain what would be absorbed upon it; but I believe, for the whole year, you could not calculate much more than one foot in depth would flow off the soil from the fall in situations where the soil is impervious; the rest would be waste and evaporation.

1250. There would be waste, evaporation, and absorption to take off a certain quantity of rain-fall, and to prevent it flowing into the tunnel?—Yes.

1251. What proportion am I to take for these different causes of subtraction?—I should consider the taking from one end of the year to the other, that you may consider upon that area there is a foot in rain-fall to be provided for, and which now goes down the sewers.

1252. It would be more satisfactory to take it this way: supposing the rain-fall to take place during 24 hours, and to yield a quarter of an inch; you have mentioned a certain circumstance under which a part of the rain-fall will be absorbed and wasted; I want to know what proportion during those 24 hours will be so absorbed and wasted so as not to go into the tunnel?—I am not able to say that.

1253. The entire quantity is 87,044 cubic feet?—Yes.

1254. To what extent do you think you can safely reduce the quantity on account of the reason which I have mentioned?—I think 13,605 cubic feet per minute.

1255. You have examined what proportion of that area you have mentioned is an absorbent area?—Yes.

1256. What porportion is absorbent; gardens and so on?—A large portion of the district; for instance, all that within the green line marked on the large plan is absorbent.

1257. Of one, two and three, what proporition consists of such surface as will absorb or waste water, instead of passing it on?—One, two and three may be taken as non-absorbent entirely.

1258. By the *Committee.*] When the drainage of those districts is improved, will they be equally absorbent?—This has only reference to the rain-fall; a drain is made, not only to carry off the sewage, but it is made to carry off a large amount of rain-fall, which is a very large material to deal with, much more than the water pumped into London. We know the quantity of water pumped into London and the sewage proper is represented by that.

1259. But, when there is a good system of drainage, would it not increase the quantity of water that is brought into the sewer?—No doubt.

1260. For instance, since the Regent's Park has been drained, do you not believe that more water is carried into the great sewer down Regent-street?—Only after rains; but it will be more regulated, because before the drainage took place, the water would flow from the surface; now it has to penetrate down fissures into the drains, and that detains it for more than 24 hours; so far as that is concerned, the sewers would be improved by having a subterranean regulating reservoir, as it were, constructed in that part of the metropolitan district.

1261. Do you mean that the more complete the system of drainage is extended over the metropolis, the more the flow of water will be regulated?—No; when I speak of absorbent ground, there is this to be said. On the top of Hampstead Heath there is a great area of sandy soil; that part contributes nothing to the sewers during heavy falls of rain, but it becomes a detaining reservoir, to give it off in the shape of springs throughout the rest of the year, and therefore there is no necessity for making the sewers larger for a sudden emergency from that district; that is what I mean by absorbing ground. It is found that sewers always in non-absorbent soils are 10 times larger than they are in absorbent soils, because the absorbent soil gives off no flood.

1262. By Mr. *Calvert.*] Just as at Hampstead, and different parts of London, there are certain portions of the ground are absorbent?—Yes.

1263. There is in every district a certain portion absorbent?—Yes.

1264. Of district No. 1, how much is absorbent?—District No. 1 we have assumed as non-absorbent; that all the water immediately runs off to the sewers within a few hours; from district No. 1 there would be heavy floods immediately after a thunder-storm; the capacity of the sewer is only required for the four hours during the storm. This diagram will represent the rain-fall, and the irregularity of it during the last two years; by this diagram it appears that there were nearly two inches of rain to be provided for in one day in the last year. (*The Witness exhibits the same to the Committee.*)

1265. Now look to No. 2; is there any absorbent ground in No. 2?—No; there is not.

1266. The upper part in No. 2 is all unbuilt upon?—It is all unbuilt upon.

1267. Then it is absorbent ground?—Where it is clay and unbuilt upon, the water runs off immediately, as well as that which is built upon.

1268. No. 3, how is it?—No. 3 is covered with houses, and I take it is now non-absorbent.

1269. Of those three districts, it is all now absorbent, is it?—Yes; and so I take it.

1270. Now explain to the Committee what will be the course of the water after the tunnel and sewers are filled up by a storm?—Those tunnels are put down so low, that no liability will ever exist of their being injured by an overflow, that is, by being filled; the ground will press them equal all round, and there is sufficient load on the top to prevent their experiencing injury from external pressure; the tunnel, when filled, will be in a state of equilibrium.

1271. When the sewers and tunnel have become full, I presume the water will flow down to the Thames, just as it does at present?—Yes; but, of course, means must be provided for regulating the water at the orifices, where a large water-shed exists in those districts, and intersects this tunnel.

1272. By the *Committee.*] Means must be provided; do you mean at the branch sewers, which join with the existing sewer?—No doubt; but such means must be provided.

1273. Some means must be provided for regulating that?—Yes, for regulating it; a number of means might be devised for letting a part of the water down, and letting the other part past, or shutting the water entirely out of the tunnel, or letting the whole go down the river; that is matter of no mechanical difficulty to accomplish.

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1274. Why do you say it must be done?—I say that there will require great nicety in the arrangement of letting in the water to the lower tunnel, and also to manœuvre the water so as to exclude a part, and let in another part.

1275. Why?—I would under no circumstances let in storm-water, because it may bring down a large quantity of pebbles and materials, which ought to be excluded; therefore, when the vein of the water gets beyond a certain thickness, then it ought to be cut off.

1276. Is somebody to be in attendance at each of these sewers to put this in motion, or is it to be self-acting?—I have always contemplated that it would be necessary to have persons in attendance, but only at those sewers which form connexion with a large water-shed; the small sewers, which have no water-shed, may be let into the tunnel, and they will go away as they now do; they will never require, in fact, to be excluded.

1277. Looking at the north branch from the Victoria-street sewer to the end, how many cross-sewers are there which would require the means of adaptation of which you have spoken?—I only contemplate those hydraulic arrangements when a water-shed, such a water-shed as I have represented here, is let into the sewer; but where there is no water-shed, then I would make an ordinary opening, and that would constitute the exhausting part of the operation during a storm, and the pumps would be adequate to master them.

1278. Will you answer the question; tell me at how many places, from Victoria-street sewer to the discharge at the reservoirs, there are junctions at which these mechanical arrangements would be necessary?—For the Victoria sewer there would be one; for the Fleet district another.

1279. For the Regent-street sewer?—The Regent-street sewer I should take on the ordinary flow; there is no large amount of water-shed around it; I should make that a permanent junction, and consider that to be sufficient.

1280. The St. Martin's-lane sewer?—And that the same.

1281. The Savoy?—And that the same.

1282. The Essex-street?—Every one of those, during a storm, the pumps would be calculated for the exhaustion of; in fact the Victoria sewer should be let in during a storm, because I do not consider it takes in a large amount of water-shed.

1283. Then the only one at which this mechanical arrangement is to take place is to be at the Fleet sewer?—At the Fleet sewer, and at the Walbrook sewer.

1284. At those two it will be necessary to have an arrangement, and to have some one in attendance?—No doubt; and some one in attendance; and possibly it would be necessary, I think, to have some one in attendance also at the Victoria sewer, to turn it down the ancient channel; but I think, with the present pumping power, that it never would be required; the great volume of water is derivable from the ancient Fleet river.

1285. By Mr. *Calvert*.] You have mentioned three different districts; it would be convenient if you could point out where they escape from; the Hackney-brook basin escapes into the Lea, does it not?—Yes.

1286. Is No. 4 the Kensington basin?—Yes.

1287. Does that fall into the Thames at Bayswater?—No, at Chelsea; but there could be no flood from that basin, because the Serpentine forms the regulating reservoir. Hampstead in some part is provided by a regulating reservoir, the waterworks deriving much water from reservoirs.

1288. That would not be touched by this scheme in any way?—No; only it has this advantage: the reservoirs allow the water to come down periodically, instead of allowing a sudden flood. If there were a large reservoir at the bottom, but that is not possible; but if it did exist there, and that the flood-water of a very heavy shower, then the rest of the water might be let out day by day, and so be regulated.

1289. The Notting-hill basin, that flows out at Hammersmith?—Yes.

1290. The Acton flows out at Chiswick?—Yes.

1291. No. 7 is the Ealing basin, and that flows out at East Brentford?—Yes.

1292. No. 8 is the Brentford basin?—Yes, and which flows out at Brentford.

1293. Letter B is the Battersea basin, on the other side of the water?—Yes.

1294. That flows out at Battersea?—Yes.

1295. Have you examined the estimate for the proposed work?—Yes.

1296. In your opinion are those estimates ample?—Yes.

1297. Have you calculated them with minuteness?—Yes, I have gone through them carefully.

1298. Have

1298. Have you examined the prices put upon each part of the work?—Yes.

1299. Do you think that those works, in point of dimensions, are fit for the duty that they have to perform?—Yes.

1300. With regard to the situation; do you observe they take the line of the streets, instead of being taken through the property of private persons?—It seems that there is no other course to pursue. You must intercept the sewers at their outlet. If you went further away from the side of the river, and made it a grander work, why, of course, other cross-drains of exhaustion to lead to the greater work would be required, and it would be very expensive.

1301. You think the course now adopted is the fitting course, having regard to the existing sewerage?—Yes, I think it is the only course.

1302. To intercept the present sewers, and to adjust them so as to draw off the sewage from those different sewers?—Yes.

1303. Incidentally there is an advantage in the way of saving great expense in compensation?—If it were to go through private property, and in that direction, the work would never be commenced; the cost would be so excessive, the demands would be so great, it never would be considered practicable

1304. With regard to the hydraulic arrangements; do you think that they are made in a way to carry off the rain-water as it is necessary?—Certainly; there is no question but these tunnels will carry off, day by day and without interruption, the rain-water, except that of the flood-water, and with great facility.

1305. With reference to the size of the tunnels; are you of opinion that they are of a fit size for the purpose?—I think it would be injudicious to make the north one larger. I think they are quite adequate to the sewage, and I think it would be quite injudicious to make them larger.

1306. You have some diagrams of the tunnel sewers?—I have them not with me.

1307. Have you a diagram of the strata to be cut through?—Yes, I have a large quantity of data as to the nature of the soil. (*The Witness explains on the diagram.*) This is the situation of the sewer; the soil, from the best data I can obtain, is here London clay. It is represented under this line and gravel above, so that one part of the sewer will be in gravel, no doubt. I do not speak with great confidence, but to that part I understand it is clay below the River Lea; but I have no data within my own reach of the nature of the soil there.

1308. You have had access to all the different means of knowledge, and, so far as you can judge, that account of yours is correct?—Yes.

1309. There are various lifts for raising the sewage water from the different levels in various parts of the work; can you explain to the Committee where these are, and how they will work?—(*The Witness explains on the plan.*) This is supposed to be Barking Creek: this is where the lift is to be, the junction with the River Thames; the lift of the engine will be entirely freed from friction.

1310. What is the height of the lift; what height shall you lift the sewage?—On an average 50 feet. If the sewage should be lifted into the river at once, and the tide falls 20 feet, of course advantage would be taken of that fall of the tide to save the engines of that much of the load; and, therefore, there would be a tunnel drawn from low water, so that the top of the lift would only be that height at low water. As the tide rises, the engine would then increase in lift in that proportion; but the estimate of the cost of working I have taken for the higher lift from the top, because it is assumed that the great bulk of the sewage will be precipitated and used for manure.

1311. By the *Committee.*] You have had great experience in pumping?—Yes.

1312. Do you consider that one steam-engine at this Barking Creek would be sufficient?—No; there are to be a number of steam-engines there.

1313. How many should you have?—There are three engines at Barking Creek of 600-horse power.

1314. Each 600-horse power?—I have taken three engines of 200-horse power each for the net average amount of sewage and rain-fall, supposing the rain-fall was distributed every day in the year, but that cannot be, and therefore I assume the sewage must flow into this tunnel during the rain-fall: I estimate that 500-horse power would be required to exhaust the tunnel from that extra rain-fall, making altogether 1,100-horse power; but then the 1,100-horse power will only come into operation in the proportion of days represented upon this diagram. I take for rain-fall one foot in the year.

1315. How many engines shall you have available for the purpose?—Three engines, of 200-horse power a piece, and two engines of 250-horse power each.

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1316. Shall you apply the power according to the quantity of sewage to be lifted?—Yes, and only on those days when it is found at the lower end of the tunnel that a large amount of water is coming down; of course rain-gauges would be placed there, and people watching those gauges would very soon know when they must begin to pump.

1317. You would have adequate power of those two engines when required?—Exactly so; it would not be proper to adopt only the net power; to the net power we generally estimate 1-3d extra power for duplicate machinery; the 500 to 1,000-horse power only being used, perhaps, 30 days in the year, and would be the duplicate machinery required.

1318. Give us the power on the south side?—The south side is 180-horse power for ordinary use.

1319. Would that be sufficient?—That would be sufficient.

1320. By the *Committee.*] There are two places on the south side where there is to be pumping, are there not?—No, only one, and on the south side; in consequence of there being no provision existing as it does on the north side, such as the Serpentine River and Hampstead Reservoirs; to detain the rain, I find 205-horse power are wanted for extra pumping there and duplicates.

1321. By Mr. *Calvert.*] There is one part of the works in the neighbourhood of Greenwich where there is a lift of 51 feet; is there on the south side?—Yes.

1322. Then you will apply the hydraulic power?—Yes.

1323. Then you will apply this power?—Yes, 335-horse power.

1324. That would be applied at Greenwich?—Yes.

1325. Shall you have any other horse-power applied to the south side of the river at all?—No, except such engines as will be required, if they precipitate the solid matter in water; then engines and scooping-wheels would be required for manœuvring; the water in the reservoir, I do not speak of that power.

1326. That is the actual application of horse-power at Greenwich; and there the sewage will flow down to the spot, where it will be clarified, and then pass into the Thames?—Yes; I think the misapprehension has taken place about two lifts on the south side, from the fact, that the lift on the south side is some distance from the discharge in the marshes; it would have been almost impossible to have driven out the lower level to that point, because it would have come into chalk, the blue line representing chalk upon this map.

1327. By the *Committee.*] I understand you now to say some steam-power will be required for manœuvring the water in the reservoir?—Yes; I think that is most likely to be the case.

1328. And that is an essential part of the profit of the scheme to manœuvre the water?—Yes; no doubt. What I allude to with regard to that is, that if the whole body of water was lifted to a higher level, so as then to let it fall into a precipitating reservoir, it would get a net altitude added to the total lift of 10 feet; that would be a perpetual expense, supposing you do not get on with the precipitation sufficiently fast; then the lower lift is going on discharging by the main, and you save the engines extra lift by those means.

1329. By Mr. *Calvert.*] There is a great peculiarity in the pumps for pumping sewer water, is there not?—Yes; it is a most difficult thing; the designing large pumps for low lifts in the Haarlem Mere; we had a Dutch commission sitting for 18 months on the question of pump valves, and buckets; and here it is more essentially to be guarded in that respect to this question than anywhere else I know of, because materials would find their way down the sewer, and it is necessary to have solid plunger-pumps, going through stuffing-boxes, in order that the solid materials may not follow the solid plunger-pump; pump-barrels would be cut to pieces. In point of fact, there are in pumps of this description no pumping-barrels; it is requisite to adopt what is termed a stuffing-box cylinder, making the stuffing-box the working surface, and the solid plunger acts instead of an internal barrel.

1330. In valves necessary for this kind of work great care is requisite?—Yes; the materials will get under the valves, and prevent them getting back again to their seats; it is necessary that all the valves be formed upon cones, and at a considerable distance from the lower receptacle, so that the materials would not follow; it is necessary to have three or four times the area of valve room than ordinary, in order that no extra velocity in the water is occasioned by passing through the valves; but all those works may be used very simply, and can be very easily executed.

1331. There

1331. There must be a mechanical arrangement for distributing the sewer-water through the precipating reservoir?—Yes.

1332. Explain to the Committee what that will be?—I am not prepared on that point at present; when the question of this mode of using the water afterwards comes before the Committee, then I will produce the drawings.

1333. Can you give the description of the machinery that is necessary for dissecating the solid matter?—That will come at the time I am alluding to.

1334. You have drawings that will enable you to show that?—Yes.

1335. Explain to the Committee the mode in which the purified water will be discharged into the river?—That is combined with part of the general operation which I alluded to before. I believe that it will be necessary to have a scoop-wheel and engine-power to lift the water with great rapidity from the precipitating reservoir, in order that the small amount of reservoir room should be adopted; it will take a very large area for that reservoir, and it is necessary you should have the largest amount of velocity of sewer water passing through them, so that the greatest amount of work may be done in the shortest time, in order to economise space.

1336. At what part of the tide shall you discharge the water into the river generally?—Assuming that the sewer-water has not all the solid matter precipitated, then you will go on discharging into the river at all times, but otherwise the reservoir must be placed so high that it would not discharge perhaps under some 6 or 7 feet below high-water mark.

1337. By the *Committee.*] Why should the reservoirs be made at Barking Creek, instead of at Bow Creek?—I think that they might be made at Bow Creek; I quite coincide with the opinion that Bow Creek would be far enough to go, and it would save 100,000 *l.* in expenditure, and it would cut off the most doubtful part of the undertaking; it may turn out that the subsoil is entirely clay; but I do not pledge myself to any part below Bow Creek.

1338. There is a great population all about Bow Creek?—The population has been increasing about Bow Creek, and docks are being constructed there.

1339. You gave an answer just now—perhaps I did not catch it quite correctly—it was with regard to the time of tide at which you would allow this water to escape, supposing the water is clarified; I suppose it may escape at any time?—If the water is clarified, you may take advantage of the tide, or at all times discharge it.

1340. It does not signify when?—No.

1341. If it is not clarified, you must take it at a time of tide when it is sure to be carried out?—If it is not clarified, and the works are taken down to Barking Creek, as they are shown by the present plan, then, of course, the water may be distributed at any time of the tide; but if they put on a larger power on the pumps, and do the work in about 18 hours, they will have less load on the engine, because of the tide being out.

1342. By the *Committee.*] You cannot put away the water until you have got the manure out of it?—No, if a profit is to be made out of the undertaking.

1343. By Mr. *Calvert.*] Would it be necessary to build tidal gates in connexion with the reservoir?—Yes.

1344. What kind of gates would it be necessary to have?—The tidal gates which I would use, and which I have used very often upon reservoirs, are large gates, that allow the smallest possible quantity of water to flow away in the thinnest film, so that we take advantage of the ebb of the tide to remove the load from the engine as quick as possible. Those gates are often adopted for scouring out of harbours; they are merely a large gate, working upon a pivot, one side of the gate being rather larger than the other, so that the outflow of the water gives the necessary power for removing the gate.

1345. And you get the largest possible outfall?—The largest possible width of outfall, and the smallest possible depth. In a great work of this sort, every inch you can save from the load of the engine is of the greatest possible consequence.

1346. With regard to the reflux of the water, would that be prevented by the tidal gates?—Yes, it would; they shut up perfectly tight.

1347. So that the water could not come back again?—No.

1348. How long do you think it would take to construct these works?—I have not looked at that question; they would begin in so many points at once. If it were a material thing to execute them in the shortest possible period, there is no one division of the work that would take more than 12 months.

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1349. By the *Committee.*] The whole tunnel?—I do not apprehend it would be done in 12 months.

1350. That would depend upon the amount to be expended?—It would depend upon the amount to be expended, and on the exchequer of the company.

1351. And on the rate they may have their call?—Exactly so.

1352. By Mr. *Calvert.*] Here I have an estimate on the north side; the total is 632,622*l.*?—Yes.

1353. And on the south side 332,266*l.*?—Yes.

1354. Do you think those are sufficient?—Yes.

1355. Mr. Brassey is higher?—There is a little difference in the engine-power; the engines were 75*l.* per horse-power, which is too much.

1356. You are acquainted with Mr. Brassey's estimate?—Yes.

1357. Take this in your hand, and explain in what points Mr. Brassey's differs from yours?—I only made an alteration in the engine-power; it was too high.

1358. To what extent was that alteration made?—The difference between 50*l.* and 75*l.* per the horse-power. I had no doubt my estimate for the necessary quantity of horse-power is less than the other.

1359. You disagree with Mr. Brassey as to the quantity of horse-power to be required?—In this case it is such a fluctuating power to be used, that I may take a different view of it from what other people may; I have taken the power which I think will be absolutely needful, and no more, except duplicates.

[Adjourned till To-morrow, at Twelve o'clock

Mercurii, 8° die Junii, 1853.

LORD SEYMOUR IN THE CHAIR.

Mr. *Joseph Gibbs*, re-called; further Examined by Mr. *Calvert.*

Mr. *J. Gibbs.*

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1360. WITH regard to the quantity of sewage-water, do you anticipate that that will vary in the different hours, one hour from another?—Yes; it will do so in those districts where a very small water-shed is behind the outlet of the sewer; but where there is a water-shed behind the outlet of the sewer, it will vary much less.

1361. Would it vary hour from hour, according to the habits of the inhabitants of the district?—No doubt it would; there is a variation in the discharge of the sewers in the east end of the town, as compared with those at the west end of the town.

1362. Will those variations bring the bulk of the escape sewage to the same hour at different parts of the town, or will they, according to the habits of the different inhabitants of different parts of the town be at different hours?—It will, of course, be different at different hours.

1363. So that you will not have the rush of the bulk of sewage in all parts of the town at the same hours?—No; I believe that in such a very extensive drainage as this, that in a great measure it will be self-regulating; one irregularity will counterbalance the other in a great measure.

1364. At the same time I suppose there will be certain hours of the 24 hours during which very little sewage will pass; between 12 at night and six in the morning?—It will be much less.

1365. Now, the grounds of your calculation and the quantity of sewage are, I believe, three-fold, are they not?—Yes.

1366. You take the measurement and the report of Mr. Hawkins, which gives about 10,000,000 cubic feet per day?—Yes.

1367. You take also the quantity of water supplied from the water companies?—Yes.

1368. And

1368. And three per cent. added for springs, which gives you about 9,600 cubic feet?—Yes.

1369. You take also the report of the city surveyor, which gives you as much as 12,100,000 cubic feet?—Yes; that is from the area of the water-shed, which is of an extensive character, extending nearly up to Brentford.

1370. Now, having regard to these different sources of information, do you think you are quite safe in putting the quantity at something about 10,000,000?—Yes; of course there will be times on a few days in the year when that will be exceeded.

1371. Now, in speaking of the escape of sewage yesterday, you mentioned that in one or two places in the tunnel, there would be elbows?—Yes.

1372. Which would tend to check the escape of the sewage?—Yes.

1373. I want to know whether, by making the tunnel larger in those places, the tendency to prevent the escape would, in point of fact, be diminished?—Yes, it would. I stated the minimum amount which would flow through it; the maximum amount, of course, would be much higher; 20,000 cubic feet per minute would be the maximum amount. The care which is bestowed in constructing the tunnels at those bends, will also increase the amount ranging between the fifteen and the twenty millions.

1374. In short, will such care with respect to the size of the tunnel at those elbows, insure you generally attaining your maximum of 20,000,000?—Yes, with very great care of construction.

1375. *Committee.*] By care, do you mean care in the curve adopted?—Exactly so.

1376. Mr. *Calvert.*] With very great care in the construction of the elbow, are you able to ensure an escape generally amounting to 20,000,000, as you put it?—Yes; no doubt of it.

1377. Now, I will go to one other subject: I think there was a little inaccuracy in part of your evidence as to the rain-fall; I believe you have made a map, have you not, of the basins No. 1, No. 2, and No. 3?—Yes.

1378. Now, can you distinguish in basins No. 1, No. 2, and No. 3, that which is absorbent and that which is non-absorbent?—Yes.

1379. I think you stated that the whole of No. 1, No. 2, and No. 3, would be non-absorbent; is it the case that there are certain parts of No. 1, No. 2, and No. 3, which will be absorbent?—Yes.

1380. Have you, in that plan which you now submit to the Committee, distinguished such quantity that will be absorbent, and such quantity as will be non-absorbent?—Yes, I have.

1381. Just lay that before the Committee?—Yes. (*The Witness handed in the plan.*)

1382. Now, you have also in that plan drawn out the other districts, 9, 8, 7, 6, 5, 4, 10, C and D, from which the sewage will come into the tunnel, but the rain-fall will go into the Thames?—Yes, from which sewage may come; but at present there is no arrangement; that will require a co-operative arrangement between the Commissioners of Sewers and the Company to effect that object.

1383. The rain-fall will not come from those districts into the tunnel at all?—Certainly not; that is so.

1384. Will the sewage come from No. 10?—No.

1385. Will it come from No. 4?—No.

1386. *Committee.*] Where does the sewage from No. 10 go?—The sewage from No. 10 discharges into Hackney Brook.

1387. And from Hackney Brook?—Into the River Lee, high up beyond the tideway, or close upon the tideway; I believe it is above the tideway.

1388. Mr. *Calvert.*] Now, I believe, in this plan you have included the whole of what is put by the surveyors within the 47 miles?—I have no means of knowing what district they include in the 47 miles; but I apprehend it comes nearly to the same amount.

1389. Have you drawn this plan for the purpose of showing what portion of the 47 miles square will, in fact, have a rain-fall flowing into the tunnel, and what into the Thames?—Yes; that is the mode in which I have constructed the plan.

1390. Having regard to Nos. 1, 2, and 3 on the north side, will a quarter of an inch rain-fall upon those districts yield 6,325 cubic feet of water?—Yes, it will.

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1391. Then add that to the daily flow of sewage per minute, 4.776 feet, will that give you, as the total quantity to be conveyed into the tunnel, 11,101 cubic feet per minute?—That is so.

Cross-examined by Mr. *R. Gurney.*

1392. I understand you to state, that from all these uncoloured districts none of the rain-fall, in your opinion, will pass immediately the tunnel?—No; there are sewers, the nature of which we do not know, where water is brought already from one basin into the other; of course, that I can take no account of.

1393. What is the amount of that exception?—That I have no means of knowing.

1394. You have no means of knowing at all?—No.

1395. Then do I understand you to be in a state of ignorance as to what becomes of the rain-water from all these uncoloured districts?—There is no ignorance at all in the matter. I know the water-shed surrounding London intimately for a great many years; I have made a great many surveys of it; and that represents what I should call the basins, which flow into the river surrounding London.

1396. Do I understand you to be able to state, or not, that none of the rain-fall in any of these uncoloured districts will pass into the tunnel?—It will be so, except such as is contiguous to No. 2.

1397. Now take, for instance, or let us begin at the extreme end, No. 9; what district is that?—No. 9 is the district of the Brent; that comprises——

1398. I will not trouble you as to that; I will not go so high as that. Take Pimlico or Parliament-street, wherever this tunnel begins. In which of these divisions would the Victoria Sewer come?—In No. 3.

1399. What is the main outlet for No. 4; what district does that take?—The main outlet for No. 4 will be the part coming from Kensington; that drains Kilburn, and gives the name to the bourne—Kilbourne.

1400. Is it the King's Scholars' Pond Sewer, as it is called?—It may be; I do not know the outlet.

1401. Whichever was the outlet, would there be an immense quantity of sewage to pass through there?—No doubt.

1402. Then is it as much as any other part of London?—Yes; I should think it was as large.

1403. That, then, you do not propose to relieve the river from?—I beg pardon; I do not assume anything of the sort. I say that the present works only come up to Parliament-street; beyond that will depend on the arrangements which the Commissioners of Sewers think proper to make; they can take that sewer into this now proposed.

1404. If you take that sewer, then you would take the rain-fall?—No; because an arrangement ought to be made for excluding the rain-fall, or a large portion of it; for instance, there is a large compensating reservoir for that district; a portion is diverted into the Serpentine.

1405. Is a portion of the rain-fall without the sewage diverted into there?—No; it is diverted into it with the sewage; there the separation ought to take place; but it has not taken place.

1406. That is not contemplated under the present Bill?—No; that is a work for the Commissioners of Sewers to carry out, and which they might have carried out long since.

1407. And which they might carry out without the intervention of this Bill?—They might, so far as diverting a large portion of the sewage from the Serpentine.

1408. But when all the works authorised by this Bill are constructed, as I understand, the whole of the sewage that passes into King's Scholars' Pond Sewer will still pass into the river?—It will, unless, as I said before, the Commissioners of Sewers think proper to divert a large portion of it into this proposed sewer.

1409. Does the same apply to the Ranelagh and Counter's Creek Sewer?—No.

1410. Are those sewers through which a great quantity of sewage is passing?—Yes; but the Counter's Creek is a tidal creek, as well as a sewage place.

1411. But that does not make any difference?—No; the sewage would want to

to be taken higher up. If the Commissioners of Sewers would take a sewer above Counter's Creek, then the sewage can be diverted into this proposed sewer, and the rain-fall may be excluded.

1412. How will the rain-fall be excluded?—By the means which I stated yesterday; that when the rain-fall is beyond a certain point, that is, beyond the capacity of the sewers, then it should be excluded.

1413. As I understand you, the sewer is to provide for all under a quarter of an inch?—I do not give that as my opinion; a quarter of an inch is stated by the surveyors and the engineers belonging to the city and the Metropolitan Board of Commissioners.

1413.* And by Mr. Mitchell, the engineer of the Company; did you not hear Mr. Mitchell state that, in his judgment, the sewer ought to provide for all the rain-fall, except that which would fall in 23 or 24 days in the year?—Yes.

1414. Which would be all exceeding a quarter of an inch?—Yes.

1415. Do you agree with him in that opinion?—No, I do not; I do not think it is necessary; in fact it is difficult to say what the effect of a quarter of an inch of rain is on the sewers. There are no rain-gauges established at all within the metropolitan districts for the purpose of testing the increase of sewer-water at the time of rain-fall: until that is established, and it ought to be established, you cannot tell the quantity of the water which will come down, or that part of the rain-fall which ought to be excluded.

1416. Then do I understand you that there are not sufficient data at present for deciding the question how much of the rain-fall should be provided for by the works to be constructed in relief of the river?—I mean to say this; that if this sewer is constructed—and no one can doubt it ought to be constructed—that it will carry off the sewage; I have no doubt on the subject myself, and a great many more are of the same opinion. Then, I say, the amount to be excluded in respect to rain-fall from those great outlets, which represent the outlet of the rain-fall basin, could be estimated and settled as to the proportion which should go into the sewer during the fall of heavy rain.

1417. Do I understand you or not to give any opinion as to what proportion of the rain-fall should be provided for by the tunnel?—No; I say here is a tunnel large enough for carrying away 20,000 feet per minute.

1418. Whether it is large enough, we will see when we ascertain what is to pass into it; I want to ascertain what is to pass into it. I ask what proportion of the rain-fall you think should be provided for?—You must, first of all, ascertain on what district, because that is so general a question.

1419. I will take the district which you describe as the urban district, the numbers 1, 2, and 3?—Then I say it would be a most unreasonable proposition to carry the water falling from Ealing, for instance, which is not very much contaminated, into a sewer which is to be so expensive in its construction, and then go to the annual expense of pumping.

1420. Ealing is not in 1, 2, or 3; I am taking your own district?—Then, I say, within that district you may take a quarter of an inch of the rain-fall.

1421. But you have put a quarter of an inch of fall, and a quarter of an inch would give 403 feet a minute, for every square mile?—Well; that I cannot tell you now.

1422. There are certain tables published on that?—No doubt there are.

1423. *Committee.*] That varies very much in different parts of the country?—Yes, of course it does.

1424. Mr. *Gurney.*] I am taking a fall of a quarter of an inch over a square mile?—That is so general a question that it means nothing.

1425. I really think we need hardly go into it; it must be your own calculation; you have proceeded upon it?—I have no doubt it is correct on the impervious strata; but you must first of all settle that there are no receptacles in the district for receiving water, in the shape of compensating reservoirs; and you must also settle that no part of the earth in the district absorbs water.

1426. You can take what is absorbent and what is non-absorbent; take your own figures of your own non-absorbent part; you calculate a quarter of an inch of rain-fall to produce in the non-absorbent parts 6,235 cubic feet a minute; is that so?—It is so, and I wish to give the most explicit answer I can to the question; but at the same time the question is not at all applicable; because within the district No. 2 there are large reservoirs for collecting water for the purpose of supplying the water to the Hampstead district. Four millions of gallons per

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annum are delivered for house use in the Hampstead district, and a very small portion of that is pumped from the wells, the rest being supplied from reservoirs.

1427. Is it your own calculation, that a rain-fall of a quarter of an inch in the 24 hours will produce per minute a flow of 6,325 cubic feet?—Yes; I have so taken it.

1428. That is, excluding all that you describe as the absorbent parts?—Exactly so; but I do not mean to say, and I wish it to be clearly understood, that it is not my opinion that that quantity of water, when a quarter of an inch of rain falls, will come down, because there are those countervailing causes before spoken of within the district which will detain a very large proportion of the water in the reservoirs.

1429. When the ground is soaked?—It depends on the time of the year whether the ground is soaked, or whether it is not.

1430. Now, taking your own calculation of 6,325, does that assume that the quarter of an inch would fall equally throughout the 24 hours?—No; but it would take 24 hours to run off; it may fall within half an hour.

1431. Now, is it your opinion that it would run off equally for the 24 hours?—It depends, as I before stated, on the nature of the soil.

1432. I am taking the non-absorbent soil; I am confining myself entirely to that?—But even there it will depend on the tortuousness of the passages through which it has to flow, and the distance it has to run over.

1433. Am I to understand you to state it as your opinion that it will flow equally for 24 hours?—I do not say that it will flow equally for 24 hours; I say probably it will take 24 hours to flow off.

1434. Will it not flow very unequally during those 24 hours?—In one part of the district it will flow off almost immediately, and in another part of the district it may take more than 24 hours to run off.

1435. I am confining myself entirely to the non-absorbent districts?—Exactly so.

1436. I ask you whether you state it will flow equally for 24 hours or not?—In one part of the district it will flow off almost as fast as the rain falls; in the city, for instance, where it is very near to the outlet, and where the streets are paved, the water immediately finds its way to the river; but in the Hampstead district it will not find its way for some time, and that detained by reservoirs not at all.

1437. Take, for instance, first of all, the paved part of London, the metropolis?—Yes.

1438. How many acres would that be?—That I cannot tell.

1439. You say there are 11 acres of this non-absorbent; how much of that is paved, or gutters?—I cannot tell you.

1440. Is the greater part of it?—No.

1441. About how much?—It is impossible for me to draw a conclusion as to that question.

1442. Is it not very important, in order for us to arrive at a conclusion as to the quantity to be discharged in any one hour?—It is not at all important for this question.

1443. But I am not asking you whether it is important to this question; is it important in order to enable us to know what quantity will flow into the river in any one hour?—It would be desirable that gaugings should be placed, to know what quantity does flow in any one hour; but those gaugings ought to come rather from your side of the question, in the shape of information, than as a general answer.

1444. You think the opponents, and not the promoters, of the Bill should furnish the necessary information in support of it?—Of course I cannot look upon the Metropolitan Commissioners as the opponents of a great measure of this description.

1445. As soon as ever they are satisfied it is a good measure, they will adopt it; at present we are testing the value of your knowledge on that subject. Now, I am asking you, supposing the quantity of water falls that you speak of, a quarter of an inch in the 24 hours, whether, in your judgment, there would not be, during some of those hours, a far greater quantity than 6,325 cubic feet passing into the tunnel?—No, I cannot say that that would be so.

1446. That is the quantity, supposing all flows equally for the 24 hours?—Yes.

1447. Then, if it flows unequally, there would be a larger quantity for that time?—No doubt.

1448. How

1448. How much larger you cannot tell?—No. When I alluded to gaugings, I would not value gaugings in such a case as this, unless the gauging was carried on for a series of months, or a year.

1449. Will you tell us what you would value as affording information on this subject?—I would value, of course, every information that could be brought to me bearing on the question.

1450. I want to know what information would satisfy you?—I would value gaugings, no doubt about it; every one who has to deal with water would do so.

1451. Now you put, I observe here, as the quantity of the daily flow of sewage at 4,776?—Yes.

1452. How do you arrive at those figures; Mr. Mitchell gave us upwards of 7,000?—I arrive at it in this way: I consider the quantity of water pumped into London represents, in a great measure, the quantity of water flowing away from it; provided the rain-fall of the district is added to that, and that will give us a very accurate opinion of the quantity of water which flows out of it, taken from one end of the year to the other. Now, the water supplied on the north of the river is 35,000,000 of gallons, and the rain-fall, day by day, may be taken, if we assume 12 inches in the year beyond evaporation, at 7,000,000 of gallons; that together would give 42,000,000 of gallons as the quantity of water within the influence of this sewer on the north side of London.

1453. Do you say 35,000,000; Mr. Mitchell, I am told, gave it as 45,000,000?—That would be from the north and the south, probably; I should say that that is an over-estimate.

1454. *Committee.*] Which part is over-estimated?—I think there is not that amount.

1455. Which do you mean?—There are deductions from that which I cannot arrive at at all.

1456. Is the 35 correct?—The 35 is correct.

1457. Then you think the seven of rain-fall is incorrect?—The rain-fall would be very likely to be over-estimated; it is no doubt over-estimated, from the average of years, that is, after deducting evaporation, but evaporation in London must be larger than evaporation in the suburbs; there can be no doubt of it, from the large quantity of fuel that is consumed, and also from the nature of the streets, and various other things. We know very well that when the streets are watered, that the whole of that goes off by evaporation, and that must be deducted also from the 35,000,000 of gallons; but then, in addition to that, and as a set-off to it, there is a large quantity of water pumped from wells, the amount of which we have no means of gauging, so that I think 42,000,000 of gallons taken on the north side within the district comprised in No. 3 and No. 1, and the absorbing district also, is a fair estimate of the quantity of water which may be expected to flow out of it day by day.

1458. *Committee.*] Are not the wells supplied from the rain-fall?—Yes; you are quite right; but we have two sorts of wells in London, the one a local well, deriving its supply from the surface-water in the gravel, the other a deep well, deriving the supply from remote springs.

1459. There are a good many of those?—A great many, and a large volume of water is pumped from them into the district.

1460. Mr. *R. Gurney.*] First of all, as to your proceedings, you say 35,000,000 of gallons are supplied daily to the north of London?—Yes.

1461. How much do you assume the New River to supply daily?—I take it from their quantities given to Parliament.

1462. When?—The year before last.

1463. Given by them?—Yes.

1464. What is the quantity which you assume?—Thirty-five millions.

1465. No, no; first of all the New River Company?—I have it not by me here in a separate form; I have taken the whole water supply.

1466. Do you suppose them to supply the water equally throughout the year?—No; water is supplied in proportion to the demand, and the demand will vary according to the state of the weather. In hot weather, when there is so large an amount of evaporation, that there is nothing from rain-fall going down the sewers, except on very extraordinary occasions, then the company's pumping is at the maximum; but that is in favour of my view, that I have over-estimated the quantity which can flow out.

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1467. Now, when you take 35,000,000 daily, is not that dividing the whole quantity they supply in the year by 365?—No doubt about it.

1468. Are you not aware that they deliver very different quantities at very different periods of the year?—No doubt but it is so.

1469. Would that represent the greatest quantity they deliver on any particular day of the year?—Certainly not; and I must always insist on this explanation, that when they arrive at the maximum quantity of supply, the maximum of evaporation is arrived at also; consequently the proportion flowing to the sewers is diminished.

1470. It is in the hottest weather that they supply the greatest quantities?—Yes, when the streets are watered, and so on. I wish to be very clear upon this point, because I am taking on myself to give an opinion which affects a great measure, and which opinion I should like to give correctly. I have been obliged to take the 35,000,000 of gallons pumped into these districts. I have been obliged to take that for the whole of the districts; but a large proportion supplied by the New River and other companies is supplied outside of these basins I am speaking of, but I have no means of estimating what that quantity is; therefore, when I say 42,000,000 of gallons annually is the quantity which may be expected to flow down that sewer, of course there is a deduction to be made for water pumped into the Hackney brook district, and also into Kensington, and other districts.

1471. *Committee.*] Does Sunday materially affect the supply, do you imagine?—Yes, it does; the supply of water is diminished.

1472. Mr. *R. Gurney.*] There is a very small proportion indeed delivered on that day?—A very small quantity indeed delivered; but there is a consumption in the houses on Sunday as well as other days.

1473. Will you give us the rain-fall on the south side?—The rain-fall on the south side, calculated in the same way, would be 6,958,250 gallons, and the supply by companies is 10,170,000 gallons, making 17,155,537 gallons. Then on the south side there is, no doubt, a very large evaporation; but there is also a large proportion of the district which has local wells.

1474. How much will that be a minute?—I have not made it out into minutes.

1475. *Committee.*] There is a greater amount of local wells on the south than the north?—Yes; we cannot estimate the amount of water drawn from those wells; but still those wells are principally from rain-fall.

1476. Mr. *R. Gurney.*] What was the total amount of sewage that you assumed on the south side daily?—17,155,537 gallons.

1477. That is what Mr. Mitchell stated at two millions and a half?—I do not know what he stated; I make my own estimates, deduced from my own knowledge of the district.

1478. What is the delivering power of the tunnel on the south side?—Equivalent to that.

1479. What is it; will you state what that is, if you please; on the north side you have stated it to be 15,000, as I understand?—I stated the tunnel-delivering power, supposing the water flowed down the sewer day by day, equally at 600-horse power.

1480. I meant the delivering power of the tunnel on the south side; what you gave on the north side was 15,000; you said it would be 20,000 if it were not for the bends; you made a deduction on that account?—On the south side, not making deductions for bends, 36,000,000 of gallons is the capability of the tunnel.

1481. *Committee.*] You gave us 15,000 cubic feet a minute?—No; that is on the north side.

1482. On the north side you gave us 15,000; we want to have a similar one on the south?—Four thousand one hundred feet is the extreme minimum; that includes bends on the south side.

1483. Mr. *R. Gurney.*] Is the 4,174 the capacity, supposing there were no bends?—No; it is the capacity with bends.

1484. That is what that would deliver constructed as laid down in the plans?—Yes.

1485. Mr. *Calvert.*] Now, give us the maximum?—There is the maximum, suppose the tunnel was made perfectly straight.

1486. Mr. *R. Gurney.*] Perfectly straight, and no friction?—No friction is included.

1487. Mr.

1487. Mr. *Calvert.*] What is the maximum?—Five thousand three hundred and forty it would carry, if it was a straight line.

1488. Mr. *Gurney.*] You stated yesterday, Mr. Gibbs, that Nos. 1, 2, and 3 were entirely non-absorbent; do I understand you now to give 3,000 acres as the absorbent area?—No; my calculation is Nos. 1, 2, and 3 as non-absorbent.

1489. What is this 3,840 acres; you seem now to have divided it into 10,000 and 3,800?—Yes, that includes the absorbent part; that goes through the three districts.

1490. You were asked the question repeatedly by my friend, whether you meant to state that the whole of Nos. 1, 2, and 3 were non-absorbent?—If I did, I was guilty of a misapprehension on that point.

1491. Now you say that the Nos. 1, 2, and 3, 10,035 acres, are entirely non-absorbent, and 3,840 are absorbent?—Yes.

1492. Which would retain the water for a limited time?—For a limited time, unless in case of an extreme amount of rain falling in a moment, as it were, a thunder-storm.

1493. Probably if you have been attending to this subject, you may have referred to various papers that have been published on the subject of the construction of sewers?—I have paid great attention to the subject of the construction of sewers in the vicinity of the metropolis for some three or four years.

1494. You have referred to the papers published by the Board of Health on the subject?—I think I have, most of them.

1495. Are you aware of Mr. Hawkesley's paper on that subject, published by them?—Yes; Mr. Hawkesley's paper is a very valuable one.

1496. Do you agree in town districts which are roofed and paved, about five-sixths of the rain will, after the first few minutes, run off the surface as fast as it falls?—I say that is a very general question; but there is no doubt that in closely built towns, well paved, that the water will run off immediately if there is a large slope. But it will depend very much as to the proximity of the houses and the nature of the sub-soil.

1497. Do you think that is not accurate?—I cannot say that it is or is not.

1498. Have you no opinion on the subject?—I have no coinciding opinion with respect to that question.

1499. Have you any differing opinion?—No, I have not. I should say that Mr. Hawkesley is generally correct on those matters.

1500. Is the inference drawn from that a correct one; supposing that to be true, that sewers must therefore be provided of a magnitude sufficient to discharge in each minute a number of cubic feet of water equal to 100, multiplied by the number of acres in the natural urban area of drainage?—There is no doubt that is very correct; but it is not at all applicable to this question. Mr. Hawkesley is there speaking of sewers, properly so called, which are for the abstraction of matter from houses; but he is not so speaking of a subterranean river, which this is in the nature of, and which is to collect and unite a large number of sewers from a great many districts; and therefore I say that that opinion is inapplicable as regards this present case.

1501. The opinion itself you say is no doubt perfectly correct?—I believe Mr. Hawkesley is correct in what he states.

1502. If sewers must be provided of that magnitude, it is because the water that must pass into them is sufficient to fill them?—No doubt; he is alluding, I have no doubt, to an inch and a half of rain.

1503. How would that apply to those districts, the water of which necessarily passes into this tunnel?—It applies as far as it goes.

1504. And how far is that?—To a very trifling extent.

1505. Does it apply to those districts, the rain falling on which passes into this tunnel?—No; that applies to where there is no water-shed; it would apply to a part of the city where there is no large amount of water-shed behind the outlet.

1506. Would it apply to the districts which were paved and roofed?—No doubt it would.

1507. And in this case all those districts have an inclination towards the tunnel?—No; London is placed unfavourably in that respect.

1508. The districts on the north side; I am speaking now of the north side?—I say the city has a very excellent slope, and there it would apply; West-

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minster is more distributed, and has not a very good slope. It is very flat and very unfavourably situated for drainage; and, therefore, the water will pass much slower down in the Westminster district than it will in the city.

1509. All communicating with the Regent-street sewer will flow well down, will it not?—The Regent-street sewer, if I understand it aright, has a double operation to perform; that is, it brings water from houses on each side of it; but it drains also what might be almost called the agricultural part of London, the Regent's-park.

1510. Which has been recently drained, has it not?—Yes, and consequently will send the water down in a more equal manner than it does now.

1511. Is it not the effect of draining, and has it not been found in all the districts of the country which have been much drained, that the rivers have been more flooded at times in consequence, and more empty at other times?—That is a very debateable question; I am not at all inclined to give a general answer to it. I have had a very large experience in draining districts, and in draining agricultural estates; and the conclusion I have come to is, that draining the land is calculated to allow the water to come down in a more equal manner than it does now; that is, when the ground is exhausted by previous draining of its water; it then becomes a subterranean reservoir for holding a considerable quantity of water, and detaining it for a time, which otherwise would have flowed the more rapidly from the surface.

1512. Are you not aware that it has been discovered to be one of the principal causes of the failure of the salmon fisheries in Scotland, the draining of the land there, which causes flood at one time and almost empty rivers at another?—No, I think it is not so.

1513. You say that is a very debateable matter?—It is; but I still adhere to the opinion I have just given.

1514. In that opinion you are rather singular?—No, I am not; and I have had great experience in draining.

1515. Is it not an opinion in which you are nearly singular?—It is probably an opinion in which I may differ from other people of considerable experience.

1516. You think it is a matter yet to be determined?—It is.

1517. Are the reservoirs to be covered?—The reservoirs are to be covered in case the sewage is turned into a commercial article; they are arched over.

1518. How do you mean?—Suppose the material held in suspension in sewage matter is to be precipitated, then it will be necessary to arch over or vault the reservoir, so as to detain the ammonia.

1519. Is it not determined whether it is to be precipitated or not?—I understand it is to be so.

1520. Then the reservoirs are to be covered?—The reservoirs are to be covered.

1521. In what way are they to be covered?—Arched with brick.

1522. What is the size of the reservoir?—On the north side, 50,856 square feet; on the south side, 14,484 square feet.

1523. Are you sure about the south side?—Yes.

1524. Will you just look and see whether you gave me the right figures on that; I am told there must be some mistake about that; what is the area; because there are 40,000 feet in one acre?—One is an acre and a sixth, and the other is a third of an acre.

1525. Is that the whole extent?—Yes.

1526. I thought it was 30 acres, or something of that sort?—No; but I see on the plan there are reservoirs marked; I believe the intention was to pump water into those reservoirs, and allow the water to precipitate by its own natural means, and then to draw off the surface water after the precipitation had taken place, and then merely to take out the mud afterwards; that would have been a very annoying operation to the neighbourhood, and very unnecessary; for after the water has become clear by precipitation, still the fertilizing material would have remained in it.

1527. How many hours' supply is the reservoir to hold?—These are supposed to take the whole of the 24 hours' supply.

1528. You have given me the solid contents of the reservoir?—No, that is the area.

1529. What is the depth?—The depth is 10 feet.

1530. Will

1530. Will that hold 24 hours' sewage?—No, it will be discharged 16 times in the 24 hours.

1531. You told me it was calculated to hold the 24 hours' discharge?—I then made a mistake; I meant that it was calculated to perform the operation of precipitation, and separating the solid contents of the sewer during the 24 hours.

1532. That will only hold an hour and a quarter's supply, on your own showing?—No, it will.

1533. What did you mean by saying it was calculated to hold 24 hours?—It was my misapprehension, undoubtedly, if I said so.

1534. How long is the process of purifying, or whatever it is, to take place?—It is only precipitation, and within an hour; in fact, I understand it precipitates at once: but other persons will speak to that part of the question.

1535. I am told I am mistaken about the hour and a quarter; it is considerably less; how long is it?—It is 16 times in a day; it is under an hour.

1536. They tell me it is half an hour?—It precipitates at once; the moment the water is in, then the precipitation commences.

1537. Supposing the reservoir to be empty, will it be filled in half an hour?—Yes, in less time than that, of course.

1538. Is there any new way discovered of precipitating this to what there was before, recently?—When I speak of the area of a reservoir, I am speaking of all the compartments of a reservoir in combination: you might apprehend I meant one great reservoir, without divisions.

1539. What sort of divisions are there to be in the acre and a quarter?—Every 20 feet in width, so that they are alternately filled and discharged. You could not pump water in the acre and a quarter of surface, and then empty it again; that I did not contemplate.

1540. How many divisions is it to be in?—Twenty-six divisions.

1541. Then that would increase the difficulty, would it not, because you could not have it all full at once, if it is divided into all these divisions?—No.

1542. Then all the available part would be filled in little less than half an hour?—No.

1543. Supposing it were in one whole reservoir, it would be filled in less than half an hour?—If it was one whole reservoir, the operation of pumping must cease whilst, and till it is ready to be charged again; but by having 26 reservoirs, the whole operation is made continuous.

1544. Assuming it one whole reservoir, is it true that it would be filled in about half an hour?—I can give no opinion as to that; it is a matter of calculation which I am not now able to make.

1545. Make the calculation?—I cannot make the calculation now; I will, at future time, give you the calculation as to the time it would take to fill it.

1546. Supposing there is only half an hour's supply that can be held in it, would that be enough?—No doubt it precipitates at once, and then the water is drawn off.

1547. Have you seen experiments tried respecting it?—No.

1548. When you say precipitates at once, upon what authority are you speaking?—I am speaking of what I know with regard to this particular matter.

1549. What do you know respecting it?—I know what the effect of putting lime into sewer-water is; I know it precipitates the solid matter instantly.

1550. Instantly?—Yes.

1551. Then you have seen experiments tried?—Yes, largely.

1552. That was what I asked you, and you told me you had not?—I understood you to ask me whether I had any practice in this matter, and I tell you I have not.

1553. Are you aware that experiments have been tried on a large scale by Mr. Wicksteed, at Leicester?—Only by hearsay; I understand they are large.

1554. Are you aware that it there takes an hour to do it?—It probably might, but I do not know the fact.

1555. That is the place where the experiments have been tried on a larger scale than anywhere else, have they not?—Yes; but not knowing those works, I can give no information respecting them.

1556. You say you have been devoting your attention to this some months past; have you made no inquiry as to the result of experiments, where they have

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have been tried more fully than anywhere else?—No; it did not come into my department.

1557. Have you seen any experiments tried by the Metropolitan Sewage Company?—No, I have not; I have heard of their precipitating manure by charcoal, which I think was a very expensive and not a good process for doing work of this description on a very large scale.

1558. At any time that the reservoir got full, you must cease pumping?—No; because there are alternate reservoirs, and a supply canal attached to these reservoirs.

1559. Therefore all the divisions can never be full at once?—No.

1560. What proportion of the whole of the 26 divisions might be filled for you to go on working?—I cannot say without a calculation.

1561. Will you make that calculation?—I will do so, if you wish it.

1562. One of the divisions would be filled in about a minute?—Perhaps so.

1563. Then what is the cost of the covering of the reservoir?—The total amount of the reservoir on the north of London, I think, is 10,400*l.*

1564. Is that included in the estimate?—Yes.

1565. We understood from Mr. Oglevie that there was nothing included for the covering?—There are divisions of the estimate set apart for this particular part of the works.

1566. Tell me what particular division of the estimate is set apart for covering?—I believe it is a substitution of the other reservoirs for this, or this for the other.

1567. Does Mr. Brassey's estimate apply to something quite different from that now contemplated?—No; there is a portion of the amount set apart.

1568. What is the item in Mr. Brassey's estimate which applies to this?—I will tell you; on the north side 19,852*l.*

1569. What is the item?—Reservoirs.

1570. I can find no item of that sort; there is land for reservoirs, and concrete for reservoirs; I am speaking of Mr. Brassey's. Mr. Oglevie stated yesterday that he had not included anything for the covering of the reservoirs?—No.

1571. Covered reservoirs come to less than uncovered reservoirs, according to you?—I have no doubt that the excess of the estimate originated in this way, from the necessity which was believed to exist for having very large reservoirs, and allowing the deposit to precipitate in the shape of mud, and then having an alternate reservoir, and taking the mud out, and considering that as an article to be dealt with in a commercial point of view.

1572. I suppose the plan is with respect to each of these divisions of the reservoir to pump out the water, and then remove the deposit?—Yes.

1573. What is the time that would be occupied on each of those divisions?—I think, to take the deposit out of the reservoirs, would not scarcely exceed a minute, because the flow of the reservoir is estimated on a fall of two inches in a yard, and with a great number of transverse mains to take it away, and the valves of those mains would be open all at the same moment, so that the material would run off with great facility.

1574. The solid matter has to be cleared out?—Undoubtedly.

1575. That would not flow in any way?—Yes, it will flow.

1576. The solid matter?—Yes; the solid matter will flow at a fall of two inches in a yard, because it is semi-fluid.

1577. How long will the pumping be; and then as soon as it is pumped, you will begin the other process?—Yes.

1578. How long was the pumping to be?—There is a reservoir for receiving the solid matter at a lower level, and it immediately falls into a lower reservoir, which is the regulator of the drying process.

1579. You have first of all to empty it of the matter?—Yes, which is drained from the top.

1580. How long will that occupy in each division?—I have not made an estimate of the time it will take; but I am quite satisfied that the reservoir can be filled and emptied 16 times in the day.

1581. As I understand, there is a separate process for emptying each division?—There is.

1582. How long will it take to empty each division?—I will give you at a future time the information; but at this moment I am not able to subdivide it.

1583. Do I understand that you propose to work at all times of the tide?—At all times.

Cross-

Cross-examined by Mr. *Henderson.*

1584. The first question I wish to ask, relates to the communication between the sewers and the tunnel below?—Yes.

1585. You said means must be provided for regulating the flow?—No doubt that is one of the points which will require very great consideration on the part of the Commissioners of Sewers as to the mode in which that work should be carried out.

1586. If no means whatever were used in the case of an unusual storm, the shaft which connects the tunnel would be full, and no means used, the water would then flow over, as a natural course, the top of the tunnel itself?—It would; it does not follow that that should take place, because by an estimate we could ascertain the size of the inlet at the Fleet River, and also at the Victoria Sewer. We could then narrow that inlet to an extent which should just gauge the quantity which the tunnel could carry in a proper manner, and then the tunnel would never be gorged.

1587. The orifice would be narrowed?—Yes, and that would be the water-gauge of that particular division of the work.

1588. The orifice would be narrowed so as to pass only a portion of the water?—It would be narrowed by calculation so as to pass through it a portion only of the water.

1589. You do not propose that means should be used at every one of the junctions of the sewers?—No; there are a great number of sewers which might flow at all times; there is no water-shed attached to them to any great extent, therefore the junction could be made at once. Those I say merely want a simple orifice. I do not mean a perpendicular orifice, but a proper orifice; a sloping one.

1590. Adapted as an engineer would calculate; what he supposed would be desirable to be formed?—No doubt that is so; it would also be necessary to have in one or two parts of the work up-cast shafts, as we call them in mining operations, for allowing the excess of air to be carried out from the lower ends of the tunnel, and those shafts should be built so high that no effluvia should be felt in the neighbourhood where they would be located.

1591. Will not the water flow down the orifice, whatever its size, and enter the shaft when the tunnel is full?—No; if the orifice is properly constructed in the shape of a water-gauge, similar, in fact, to that which the New River have at this moment to take in a part of the River Lea; assuming a quantity of water which ought to go down the sewer, then the excess of that would go down its own or original channel, and that would be excess of rain water, or rain-fall water.

1592. The excess then would be due to the smallness of the orifice?—Yes.

1593. Would you apply mechanical means?—Yes; to all those sewers which represent a water-shed, from which the largest rain-fall water may be expected. I would then use manual means for guarding the operations.

1594. As to those quantities which passed from those sewers, it would be dependent on the person in charge?—It would so; but there can be no difficulty upon that point, because nearly all the supply of water to London is dependent on manual inspection on the part of the people who have charge of the engines, and various other operations, and therefore the same vigilance in abstracting the water from the same district might be exercised to regulate the inflow of the water into the sewer, as is used in bringing it into the same district.

1595. Then mechanical means of checking the supply would have to be taken into account, the storm-water on the one hand, and the quantity sought to be discharged at the extremity of the tunnel on the other?—Yes.

1596. Without reference to any other considerations?—Except as to the size of gauges.

1597. By this mode of arrangement, whatever was allowed to pass would continue to go along its original channel?—Yes.

1598. I think you said that great nicety would be required in that?—No; I say that great nicety is required in the mechanical operations and in matters of this description; and great consideration is to be given to the area of these orifices which are to let in the water. It is an hydraulic calculation, which I cannot go into now, but which can be gone into; the engineers of the Sewage Commission are quite capable of settling what the size of those gauges should be.

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1599. Do you know whether those calculations have been made?—No; I do not.

1600. Under certain circumstances the tunnel would be full, would it not?—If I had the working of it, I would not allow it to be full, not at the upper end; but I would fill it at the lower end, because by filling it at the lower end you lessen the cost of pumping; it becomes a syphon, and diminishes the lift.

1601. But I would ask you whether at certain times the tunnel will be full?—It may be full, but I say it ought not to be full.

1602. *Committee.*] Why would you not allow it to be full?—Because there could be such a small interval between filling and running over that there would be no reservoir, so that I would have a certain point in the tunnel, which, when it arrived at that point of filling, then the man in charge should turn the water away; it would be regulated in the same manner that the supply steam is regulated to a steam engine.

1603. Mr. *Henderson.*] Suppose this case, that the tunnel is full when the tide is up?—Yes.

1604. Recollect the Fleet Ditch Sewer; would not the effect be to force back the sewage up towards the Victoria Sewer?—Yes, it would. I was going to say that that would be the effect.

1605. It would force it back to the Victoria Sewer, you say?—Yes, which would be a very improper thing to happen; but no one would think of making this sewer without putting an intercepting gate across it; in fact in one or two places that must be done, the same as you would put in a canal what are called stop-gates. Those stop-gates would entirely shut off the water from flowing from the Fleet towards the Victoria Sewer, otherwise you might have the Victora Sewer empty, and the Fleet full, and you would have the current in the wrong direction.

1606. If the tunnel is full, and the tide up, how can you intercept the water from flowing back?—I am supposing that the stop-gate is put higher up the tunnel than the inlet at the Fleet Ditch.

1607. That would depend on the person in charge of the gate?—Yes.

1608. *Committee.*] A circular flap, opening towards the orifice?—No; I am very much in favour of manual operation in moving these gates; circular flaps are liable to get out of order, and are not sufficiently sensitive.

1609. Then you want somebody to attend to each of those stop-gates?—No doubt; the stop-gate would be at the Fleet Sewer.

1610. I thought you said in several places there should be stop-gates?—There should be one below the present inlet; it is only in case you want to cut off a part of the sewer, and go down it.

1611. Mr. *Henderson.*] You think there should be several stop-gates?—I think there should be two.

1612. Between each opening to the river?—Yes.

1613. Is it not the fact that a great part of Westminster is below the level of the tide?—Yes, it is.

1614. In the state of things which you have been describing, would not the effect be to flood the lower portion of Westminster?—Supposing there were no stop-gate at all, and supposing the tide were allowed to flow up the Fleet Sewer, and the tide was not allowed to flow into the Victoria Sewer, the effect would be that the tide would flow through this tunnel into Westminster. There is no question of that, and mechanical arrangements must be made to prevent it; but the flood-water may go in its own channel, which is a very ancient and capacious one, by adopting these mechanical arrangements.

1615. The plan which you stated supposes a man at every stop-gate and at every sewer?—At those sewers only which represent water-sheds.

1616. And he must be there night and day?—No doubt; he must live there.

1617. A constant watchman?—Yes; the same in Westminster; there is a sewer with stop-gates; a man lives at it. It was the same on the Effra Sewer, but the stop-gates are rotten; the sewer is out of order, and the tide flows up it.

1618. *Committee.*] Is that stop-gate in the interior of the sewer, or near the outfall?—Near the outfall, but in the interior of the sewer.

1619. Has the man to enter the tunnel, in order to apply these stop-gates?—No.

1620. How mechanically is the stop-gate worked; how does the party close that stop-gate?—I believe they are self-acting; that is, they divide. I have not seen them these 15 years; I think they divide, and open outwards.

1621. They are self-acting?—Yes.

1622. There is no manual labour?—Yes, there is a man to see that the operation is properly carried on, because, without this attention, the tide might not close them soon enough.

1623. He has not to open the gates himself?—No, not to apply any force.

1624. Now you are in favour of the gate being opened by actual manual labour?—Yes.

1625. At Fleet-street?—Certainly; they would want a large space opened for the purpose of making this connexion between the sewer and tunnel.

1626. At Fleet Ditch?—Yes; and the space would be quite down to the level of the sewer.

1627. What space is there below the surface of the soil through the new sewer?—I think it is about 17 feet.

1628. The Fleet Ditch?—Yes.

1629. Not more?—I think not; but we will refer to the section. (*After examining the section.*) The soil is raised up artificially; it is 35 feet.

1630. Now how is a man who is 35 feet above to regulate a gate down beneath?—I would cut a large open space, and make a level at that part of it, which I would make like a canal.

1631. In the middle of the street?—In the water-level.

1632. But this great space is to be made in the middle of the street?—No, it must be made at the side of the street.

1633. Then you must take a house, or a space like that?—Yes, there must be some space taken.

1634. For this man to go down and reside there?—Yes, no doubt.

1635. And that must be done similarly at the other places, where you would not have one of these places; but more than one?—Yes; it is more a work for the Commissioners of Sewers themselves to perform than anyone else.

1636. Mr. *Henderson.*] You have examined the plan, and you say that does not define the size of the orifice?—No.

1637. Nor the course of the channel communication in the tunnel?—No. I do not see how it is possible that can be defined. The sewers of London are very complicated, and there is at present no plan of them that I have seen. There is a surface plan of the streets now, but made by the Commission; I can find no sewers marked on that plan.

1638. The plans that you have seen or examined are silent on what you have explained to the Committee about the stop-gates?—Yes.

1639. They say nothing about those?—No.

1640. Have this company had the benefit of your advice for a considerable time?—I was consulted from Mr. Brassey's office, as to whether this was a measure which they ought or ought not to embark in; also, to have my opinion as to the size of the sewers, and the hydraulic arrangements generally. I gave them my opinion on the hydraulic question, and my advice was, that they did not embark in it unless they did it co-operatively with the Commissioners of Sewers; but when they decided to bring it before Parliament, of course I offered to give the same testimony here that I gave to them before.

1641. Have you consulted with Mr. Mitchell, the gentleman who was examined yesterday, on the details of the plan?—Yes.

1642. Have you made any report, verbally or otherwise, of your views to the company?—No; my data were sent to Mr. Brassey's office; it was more in the shape of data than any report; I had many communications with Mr. Oglevie on the subject personally.

1643. Not with Mr. Mitchell?—Not with Mr. Mitchell.

1644. You differ, in a great many respects, from him; who is the engineer of the company?—I should state, that I think it necessary to keep this in view, that this is a plan, if I am correctly informed, of Mr. Wickstead's, who is a very excellent hydraulic engineer, and as such I viewed it.

1645. The details are in a Blue Book, are they not?—I do not remember.

1646. Have you ever had any opportunity practically, professionally, of ascertaining the capacity of London sewage water, for the purpose of precipitating and ascertaining the value of the deposit?—Yes, I have heard a great deal about

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sewage water, and I must candidly say that I think those statements have been over-estimated, but I believe that about one eight-hundredth part may be calculated upon as solid matter when dried; some of the sewers will give 200 or 300 parts of solid matter, but I should not like to rest an opinion upon more than one eight-hundredth part.

1647. It has been stated by witnesses, or through counsel, that from 500 to 700 parts water would produce solid matter?—I think one in 800 parts may be calculated upon from the sewers of London; some of them may be richer, some of them will be poorer, because there will be a varying water-shed behind them which will dilute them, but upon the average you may calculate upon one eight-hundredth part.

1648. Can you give the Committee any opinion as to the mercantile profit of the substance?—I am not prepared at this moment, but I have used large quantities agriculturally of sewage precipitation, and also other matters which form the basis of the solid matter in some sewage precipitations.

1649. Was that London sewage?—It was London sewage, and London manure, to the amount of 400 tons a year.

1650. *Committee.*] Is that charcoal?—I think charcoal is a very good manure, but I think it is very much over estimated; it was London sewage, and London manure.

1651. Mr. *Henderson.*] Did you precipitate it yourself, or was it done under your directions?—Some of it was precipitated, and some of it was solid and disinfected; you asked me the question agriculturally; I give my answer agriculturally; it is the same material which forms the basis of the solid matter in sewage water.

1652. There is a considerable proportion, is there not, of stony substances?—When I speak of the solid matter in sewage water, let it be understood that I take the floating water; not water ladled from the bottom, but taken from a considerable depth, where the water is of some considerable depth, and taken near the surface.

1653. Was it cesspool water?—It was sewage water. I will give you the names of some of the sewers which I had examined lately; the sewer which comes from Walbrook; that is the richest; the Fleet Sewer, and the Effra Sewer. The average of those will come up to nearly the amount I have stated.

1654. Was it in dry weather?—Taken now.

1655. What was the result?—I should say I have had it taken previously; many times it averaged an eight hundredth.

1656. What was the result in residuum?—I have not had it analysed.

1657. But, practically, for agricultural purposes, what was its value?—I am not able to speak to that now.

1658. It was profitable matter?—There is no question of it; it is valuable matter in an agricultural point of view.

1659. Do you know what has been called the Puddle-dock experiment?—No, I do not; I have not been connected with any experiment upon sewages; when I spoke of using manure resulting from cities agriculturally, it has been entirely on my own account.

1660. You have seen that report by Mr. Wickstead, who considered this subject?—No, I have not seen it; I only heard that the plan we are now upon was originally surveyed by Mr. Wickstead. I heard that fact about six months ago.

Re-examined by Mr. *Hodges.*

1661. Were you applied to by Mr. Oglevie on the subject of this plan; I understood you to say that you quite approved of the object he had in view?—Yes; I have expressed my opinion beforehand on that point to the Commissioners of Sewers themselves, four years ago.

1662. So long ago as four years?—Yes; I pointed out a plan like this to the Commissioners; and the only reply they gave to my plan was to put me among the competitors for designing a sewer for London. I made the communication merely on the ground of humanity, for at that moment London was suffering dreadfully by the scourge of cholera, and I made the suggestion with a view to the mitigation of that.

1663. That was the Metropolitan Commission?—Yes.

1664. Now,

1664. Now, at that time you were not aware, I believe, or when you say you thought it ought to be carried on with the concurrence of the Commissioners of Sewers, were you acquainted with the provisions contained in this Bill?—No; I had not read the Bill.

1665. You had not seen the Bill proposed by the company, and you were ignorant of the provisions contained in it?—I am; I am quite ignorant of it. I have not read it; I have the Bill by me.

1666. I am speaking of when you were applied to by Mr. Oglevie, and gave him that advice?—Yes.

1667. At that time had you the Bill?—No.

1668. Perhaps you are not aware now that the Bill contains provisions for putting this company under the control of the First Commissioner of Woods and Forests; that is clause 28?—No, I am not.

1669. You are not aware that it contains this clause, the 30th: "That the said First Commissioner may from time to time give such directions in writing as he shall think fit, to enable the Commissioners of Sewers for the time being, or other persons having the care of the district sewerage within the limits aforesaid, to use the said tunnel sewers, or any part thereof, for the purposes of the sewerage of the respective districts within their jurisdiction; and if the said company shall make default in carrying such directions into effect, they shall be liable to a penalty of for every day during which they shall neglect to carry such directions into effect. Provided always, that the company shall not be liable to any penalty until a reasonable time shall have elapsed after such notice shall have been given to them, to enable them to execute any works which shall be required for the purpose of carrying such directions into effect." You are not aware of a provision of that sort?—No; but I recommended that everything should be done concurrently with the Commissioners of Sewers, both the City and the Metropolitan.

1670. Do you not think that provisions of this sort may be framed, so as to enable the Commissioners of Sewers to use this Bill in the most advantageous manner for the public?—No doubt this work would form their outlet, uniting all their sewers, and concentrating them all into one outfall.

1671. If provisions of that sort were introduced into the Bill, would that remove the objection you had when you suggested to Mr. Oglevie that he should not go on with the scheme?—I did not recommend him not to go on with the scheme, but I recommended him not to go on unless he went on concurrently with the Commissioners of Sewers. My impression was, and has been up to this minute, that the Commissioners of Sewers naturally would promote this, and they ought to promote it, and I did not know that they were opposing it at all until now.

1672. At all events you were quite ignorant of the provisions contained in the Bill on this subject?—Yes.

1673. Now, with respect to these stop-gates, I do not understand that you would require the personal attendance of a man on any other point on the north side, except at the Fleet Ditch?—I think the Commissioners of Sewers would require, at the junction of the Victoria-street Sewer with this tunnel, that a stop-gate should be put, and that persons should be put in charge of it, with directions how to use the junction.

1674. There are flushing-gates applied to the sewers now?—There are to many of them.

1675. And men are employed to look after those flushing-gates?—Yes; and on the south side of the river there are a great many sewers that have no other means of getting an outlet, except that of having gates, drawn by men who watch the tide for the purpose.

1676. Therefore the general superintendence you speak of would be much the same as that which at present exists?—It would be so.

1677. Do you think, speaking practically, that there would be any difficulty found in sending the flood-waters into the Thames by the usual channels?—I am certain that there is no difficulty whatever in either making a junction between the tunnel and the existing sewers, if there is a disposition existing on the part of the Commissioners of Sewers to carry it into effect. Of course difficulties may be created and multiplied if there is not that disposition; but I cannot believe that indisposition to co-operate would last very long.

1678. You think that mode preferable to the plan proposed of making the

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sewer large enough to carry off the whole flood-waters?—Certainly; a sewer to carry off the whole flood-water would be an improvident proceeding; it would be a very costly affair, and would tell with very great effect through the populous part of the metropolitan district.

1679. *Committee.*] How do you mean, "tell with very great effect"?—On account of its cost.

1680. Tell against it?—Yes. This tunnel, being 10 feet, is carried with great facility up the centre of the streets; but if that is materially enlarged, it then throws in a large amount of contingency from the settlement of buildings on the side of the tunnel.

1681. Mr. *Hodges.*] Do you not think that this is a work that should be carried on without any further delay?—I believe no one has a doubt on that point, and that it is a work required; and that the sanitary condition of the metropolis cries out for it; it has done so for years. On the south side of London there is no natural outfall; a large part of Westminster is deficient in outfall; and about Dalston, Blackwall, and Hackney, and many other places, there is a great deficiency in the outfalls; and Poplar is in a very wretched state for want of outfalls for sewage.

1682. Would you consider it a misfortune to the public if this scheme were to be put off for another year?—Certainly. I put it quite beyond the question of commercial considerations.

1683. The tunnel could be made in the year, with the assistance of a large contractor like Mr. Brassey?—I see no part of the work that could not be completed in a year; but it would be unreasonable to call on the contractor to complete it within a year.

1684. Have you considered whether any difficulty is likely to occur by the system of pumping proposed to carry away the contents of the sewer at all times?—None whatever. I have had a very large experience, with myself and a colleague of mine, Mr. Dean, in pumping in Holland, where we have pumped to a great depth under the level of the tide; and we there used steam engines, with cylinders of 12 feet diameter, and pumps of 72 inches diameter, 11 pumps to each engine; and we have had no difficulty in carrying on those operations, although it was believed at the time that engines of this great size could not work as efficiently as smaller ones.

1685. You have spoken of 26 reservoirs being provided, and that they were some full and some empty; allow me to ask this, would the pumping be continuous?—The pumping would be continuous. The pumping engine is now brought to that state that you can regulate it to the greatest nicety; you can either make now one stroke a minute or nine strokes a minute, and that with very large engines.

1686. So that the lift of sewage matter would be regular into the reservoirs, and the delivery of the clarified water would be regular, whilst the drying process is going on in different stages of manufacture?—It would be so. I can state, in addition, and perhaps it is necessary to state it here, because it may be advanced against this question: that the difficulty of using pumps for lifting sewage-water may be very great, from materials getting under the valves, and so on, but we have used in these very large engines, where there has been 250 tons of load, that is, solid weight, to be lifted at each stroke, still we brought the stroke of the engine to a clear pause, resting on what we call a water crutch; that is, water in the two separate cylinders following the strike of the engine, and then a valve prevents the reflux of that water until the load of 250 tons rested upon the water, then the reflux is permitted; and by that means a large engine of this description is enabled to work, without the slightest chance of accident from materials getting under the valve.

1687. I understand you to say that these 26 reservoirs would be under a covered shed; that there would be a covered roof?—No; there is an arch over each reservoir, in order that the ammonia, which is a very valuable product, should not escape. That ammonia would be conducted to a chamber, where it would be condensed on coke, the coke being steeped in hydrochloric acid, and the coke may afterwards be ground, and it becomes then a most valuable product for manure; and every atom of ammonia being arrested, there is no smell.

1688. What I wish to ask you about these reservoirs is this: is not this a plan substituted for a very much larger plan of reservoirs, which was proposed when you first talked to Mr. Oglevie?—It is.

1689. You

1689. You have made an estimate of the cost of making these 26 reservoirs, and all works necessary to the carrying out of that plan?—Yes.

1690. Is that a larger estimate or not?—It is something smaller than the open reservoir.

1691. Do you not consider that if this tunnel were formed in the manner proposed, that it would offer a much better mode of disposing of the contents of all the sewage in London than the river at present affords; would it not be at a much lower level?—No doubt it would remove the annoyance that must exist, and will increase, from the discharge of sewage matter along the banks of the river by innumerable outlets.

1692. In that respect it would be a very valuable thing for the different commissioners to have the tunnel to drain into?—No doubt such would be the result.

Examined by the *Committee.*

1693. You said that high shafts are to be built, for the purpose of ventilating this tunnel?—Yes, at the lower end especially.

1694. At what distance apart are the shafts to be placed?—Two on the north side of the river would be sufficient.

1695. For the whole length of the sewer?—Yes, to prevent any accumulation of air and ammonia in the tunnel; and I would carry these shafts up so high, that any ammonia discharged from the surface of the sewer should be carried off by the top of the shaft.

1696. You said you had many communications with Mr. Oglevie on this scheme?—Yes.

1697. Did you give any opinion upon the size which ought to be adopted for these tunnels?—Mr. Oglevie asked me the size of the tunnels; he said that was a vital part of the question, and he asked my opinion about it; and my representation to him was that they were too large, and that the pumping power was too large: but then, when he explained to me that a portion of the rain-fall would be required, and that other districts would be required to throw their sewage into this tunnel, then I said it would be better for the dimensions to remain as they were. My opinion at first was, and my report was to that effect, that smaller tunnels would answer the purpose. I am very glad now, seeing the course of objection which has been raised, that I did not incur the responsibility of recommending the change.

1698. Is your opinion still that smaller tunnels would have answered the purpose?—It is for sewage water.

1699. Now, supposing any new sewers should hereafter be constructed for the metropolis, they must equally have an opening into the Thames as the present sewers have?—Yes, they must; but I believe then the west end of London would be much better drained, for the use of that population which will come hereafter, by a sewer carried under the River Thames, parallel to the southern one.

1700. What do you mean by under the river?—To carry a tunnel entirely under the bed of the river. There is no difficulty in doing it.

1701. Following the course of the river?—No. (*The Witness explained the plan to the Committee.*)

1702. Then, as I understand you, you would drain Pimlico and Chelsea, and that portion of the town, by a sewer which should pass under the Thames and fall under your southern tunnel?—No; I think that Pimlico can be drained by the sewer now proposed. That is, that the Victoria Sewer may be driven further west, and taken to a district which it now does not exhaust; but I think that when the sewers now proposed have arrived at their maximum, then it would be much better to make a new sewer on the south side, either parallel to this or nearer to the clayey range, avoiding the more populous parts; and that it will be made at less expense and smaller risk. Geologically, I can say that there would be no difficulty whatever in carrying the tunnel under the river, because it is clay, and is 300 feet thick at that part.

1703. As the town is greatly increasing to the west end, and as your sewer on the southern side of the Thames is, according to your plan, to take all the sewage of the increased west end, do you think your sewer, of five feet diameter on the south, is sufficiently large for that great increase of sewage?—I think the sewer on the south side might be enlarged perhaps with some advantage, taking into account the increased population; but I think when the population increases

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on the south side, that it will increase in a still greater ratio on the northern side to the west, and then that further improvement will demand a new sewer to entirely arrive at the same point down the river below Greenwich.

1704. Another tunnel sewer?—Yes; but the time for that has not yet arrived.

1705. You said, there seems to be some doubt as to the commercial value of this sewage?—No, I have no doubt whatever; my opinion merely went to this, that it has been over estimated. Some people have estimated that one two-hundredth part of sewer water might be solid matter; but I believe that has been over estimated.

1706. Do you think it desirable that Parliament should at once sanction a plan for both these tunnel sewers, or that one should be tried on one bank of the Thames in the first instance; or are you so confident, that you would without hesitation adopt both?—I believe that the wants of the metropolis require that both should be adopted without loss of time, or some other plan adopted equally as efficient.

1707. That is not quite an answer to the question. You are asked whether you think it advisable at present that both should be sanctioned at once, or that one should be tried in the first instance to see its working and its effect?—I think there is nothing at all theoretical in either side, and therefore I think both ought to be adopted.

1708. You have said that the sanitary condition of the metropolis cries out for this scheme?—It does.

1709. The scheme will have very little effect in improving a large portion of the town that now suffers, especially from want of sewage?—No; there is a large portion of the town which is not sewered, the upper part of it; but where it is more felt is in the flat districts, and which will be affected and improved by this scheme to a very large extent; for instance, Poplar, Lambeth and the borough of Southwark, Rotherhithe and Deptford, are all very badly sewered. This goes through them.

1710. We have heard a great deal of the state of part of St. Pancras?—Yes.

1711. It is stated that that district wants sewers, being totally without them; but making a great tunnel along the Strand will not benefit any portion of that district?—No, it will not; it has got its outfall now, and a capacious outfall it is.

1712. Then, for instance, along the streets where this tunnel sewer goes, there is to be no direct conduit from the houses into the sewers, but only from the existing sewers into the tunnel sewers?—No; it would be improper that it should be so, because all along the populous streets of the district where this tunnel will be carried there exists a sewer at present, and the two sewers will go parallel with each other. It is the sewer now existing, and not any particular houses which ought to be admitted into the main sewer.

1713. You said that the branch communication between the tunnel proposed by this Bill and the existing sewers, that the construction of those would be a nice hydraulic operation?—Yes.

1714. May they not also be a nice commercial operation, leaving out of account any other consideration; are there not pecuniary interests very materially involved in the way in which those branches are constructed?—No doubt of it. If this were a purely commercial operation, and they were selling their advantage to the greatest extent.

1715. Which companies do of course?—Which of course they do. The companies turning water in might have the power to exclude rain, or water not rich.

1716. They would let in the sewer water and exclude the other?—They would take that which is richest in ammonia, and consequently get the best dividends.

1717. And therefore would so construct their channels as to let in all that is rich, and then depend on the present outfalls for carrying into the Thames everything that was not worth their while?—Yes.

1718. And they would have a deep motive in that; the expense of pumping would thereby be most materially diminished?—It would be so. But what I have stated is this: that the quantity of water let into this tunnel, and the mode of letting it in, and the governing the circulation of the water through the tunnel, should be with the Commissioners of Sewers.

1719. Can

1719. Can you point out any provision in this Bill that gives the Commissioners the least control over that water?—No; I have not read the Bill.

1720. Can you point out any provision in this Bill which compels the company to construct the main tunnel of the dimensions which they speak of in the evidence here?—No.

1721. It might be equally the interest of the company to construct less tunnels than those which are proposed, having regard only to the ordinary sewage, and having taken means for excluding the entrance of any rain-water?—It would not answer the purpose of the company to embark in this undertaking if the tunnel were diminished. It is the volume of the water which will be their dividend; the company would be only interested to this extent; if two sewers existed, and one was richer than the other, and the company had the governing principle in their own hands as to the quantity they should let down and the quantity they should exclude, then I agree they would take that which was valuable, and exclude that which was less valuable. I say again that ought to be got over by giving the Commissioners of Sewers the power of sending down as much water as the tunnel would take, and also sending down that part of the water which they thought ought to be sent down; so that the company would not be making choice of either the one water or the other.

1722. Still, taking your own evidence, the capacity and power of delivery of the present tunnel is very much more than the present pure sewage-water, if such an expression may be used?—Yes.

1723. Then, assuming that the company were not compelled, might not a smaller tunnel serve their purpose so far as conducting all the valuable sewage-water, or preventing, by the size of the branch communications, anything beyond that from getting into their tunnel?—Yes, I think it is so, if there is no provision in the Act of Parliament for compelling the company to make a tunnel of the right size.

1724. Mr. *Hope.*] There is no objection to such a clause?—That is one of the points to be attended to in framing any legislative enactment with respect to this measure.

1725. *Committee.*] Assuming that there was little more than the rich sewage water carried off by this tunnel, and that in excess of that was permitted to go into the Thames, a very large portion of the benefit which it is alleged the public are to gain, would be lost?—It would be so, unless it is properly guarded in the manner Parliament may think it ought to be.

1726. And the Commissioners must, in your judgment, have full control over the size of the branch communications, and also over any machinery which may be introduced to prevent such branch communications from discharging at their full volume?—Yes; that I consider to be their department specially.

1727. You answered, yesterday, that in your judgment the scheme is not the best that might be devised, and that the company have gone further than they ought to have done?—I did not mean my answer to have that bearing; I said, that if the purifying process answers as it is expected it will do, and which I have no doubt of, then the scheme might as well stop at Bow Creek, or a little lower down, and not to be carried further; then a great saving would be made. I perhaps too incautiously observed that a saving of 100,000*l.* might be made; I think that is over-stated, that amount; the saving would not be so much.

1728. Did you suggest, when they consulted you, that they should stop at Bow Creek?—No.

1729. Do you know for what reason they have gone further?—A desire has been expressed by the Commissioners of Sewers that the outlet should be at Barking Creek, instead of Bow Creek. I think it is in accordance with the wishes often repeated by the Commissioners of Sewers; I believe that to be the cause.

1730. Will any sewer be let down in the intermediate pent?—No; there is no sewer; there is scarcely any habitation in the line of that.

1731. And the depth they would have to pump would be increased, as well as the construction of the sewer?—Yes.

1732. That would be a permanent expense?—Yes.

1733. The one is 42 feet depth from the surface of the ground, and the other 49?—Yes.

1734. That is not in itself to be disregarded?—No.

1735. You told us you had several interviews with Mr. Oglevie on this scheme?—Yes.

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1736. Did you hear at any time whether the promoters of this scheme contemplate having different men to watch the inlets of these sewers?—No; I think Mr. Oglevie did not look at those matters in detail.

1737. There is no provision in the Bill to that effect?—No.

1738. But you say it is absolutely necessary both at the Victoria Sewer and the Fleet Sewer?—Yes; and almost without doubt at the Walbrook Sewer.

1739. A perpetual superintendence?—Yes.

1740. Have you contemplated the necessity of repairs in this tunnel?—If the tunnel is made, as it is intended, of hard-burnt brick, and hydraulic lime is used in the construction, and if they take out exactly the quantity of earth which represents the area of the tunnel, no repairing will be wanted for many hundred years to come; the flooring of the tunnel, by abrasion of the water, in time may have some slight injury, but not beyond that.

1741. Give way?—No, wear away; but that is the only point where wear can take place.

1742. In the event of it being necessary to make repairs, what provision could you make for stopping the supply?—Then turn the water down its ancient channels; exhaust the tunnel from the sumpt end of it; a person could then go into it, and immediately inspect or repair it.

1743. Then the probable contingency of repairs being rendered necessary has been taken into contemplation?—Yes.

1744. What do you think would be the best size; you say you formed an opinion as to the size of these tunnels; what was your first opinion?—I do not remember the size I gave to Mr. Oglevie; but I communicated to him the size of the tunnels that would be sufficient, and he has got it; I can send for it, and deliver it in.

1745. As to these reservoirs, there are 26 of them which are separate tanks?—Separate tanks, with three feet wall between each, and stayed with iron from reservoir to reservoir.

Mr. *H. Scott* stated that they had some further engineering evidence on main tunnels, but it was not then available; but he proposed to go on with the clarifying process.

The *Chairman* inquired when Counsel intended to give evidence of the capital of the Company.

Mr. *H. Scott* stated that that would come at the end of the case.

Mr. *William Higgs*, called; Examined by Mr. *H. Scott.*

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1746. I BELIEVE you are resident in London, and are a practical chemist?—Yes.

1747. And your attention has been very much directed to the analysis of water, and earth, and minerals?—Yes.

1748. You are a patentee of a process for clarifying sewage-water, which is to be adopted by this Company?—Yes.

1749. And which is at present in use at Cardiff?—Yes; my process consists in mixing with sewage-matter a proper and proportionate amount of milk of lime, by which that sewage-matter is precipitated in a very short time, and entirely separated from the water with which it was before combined.

1750. Now the milk of lime is an inexpensive material, and can be procured in great abundance?—Quite so.

1751. You describe the process as one of great rapidity; explain in what sense you use the word "rapid"?—I mean that the matter goes down in the course of a short time, one hour finishing the operation. The matter may be pumped into the reservoir or tank; it may be precipitated, and the clear water run out within the course of one hour.

1752. On what scale are you speaking?—I am speaking on any scale, if all the conditions are proportionate.

1753. You would proportion the amount of milk of lime to the amount of sewage-water to be dealt with, and then the process would take place to any extent within an hour?—Yes, passing through proportionate apertures.

1754. What is the proportion of milk of lime necessary?—From 15 to 25 per cent.; 25 being the maximum.

1755. And the 100 being the liquid sewage?—Yes.

1756. Now,

1756. Now, does the process require the interference of any manual manipulation after the water is mixed with the milk of lime?—None whatever.

1757. How is the mixing effected?—The mixing is effected by previously preparing the milk of lime, allowing it to pass down through a pipe, where such a proportion may be regularly supplied to the sewage as the wants of the sewage demand, according to the strength of the matter, that is, according to the proportion of solid matter which the sewage-water contains.

1758. This process must take place in a tank, of course?—Yes.

1759. A receptacle?—Yes.

1760. At the bottom of the tank you make provision for taking off the material when deposited?—Yes.

1761. Is that by means of valves?—Yes.

1762. I think we have reached the point where your machinery will do more than a verbal description?—I must beg to say that this model does not refer immediately to these works, but to the principle that we are about to explain.

1763. *Committee.*] Then this refers to what you actually have done at Cardiff?—Not precisely; but the principle is precisely the same. I would illustrate, as I pass along, that this model was designed for collecting the products of life from a population of 5,000; it is on a scale of a quarter of an inch to the foot; it may be placed in any position, over a sewer, or near its mouth: this channel in the middle represents the sewer. The dirty stuff is supposed to run down the channel to be intercepted in its course, and to fall into a lower receptacle, in which an agitator or stirrer is continually going round by means of machinery above. There is a grating to intercept any gross matters from clogging the pump. From beneath it is pumped by an engine, (which propels the whole works,) into a pipe, from which it is distributed to eight tanks, each being a cube of seven feet, to which it is distributed in succession. A slide cock lets in the sewage matter; but at the same time the milk of lime having previously been prepared in a chamber above, and the lime cores being prevented from coming down into the lime tank, this lime tank being likewise agitated to prevent any settlement, a proportionate quantity of the lime is allowed to pass into the pipes through which the sewage comes, and the lime in this proportionate quantity, together with the sewage, is run into the tank by opening the slide cock. The tank having been filled, it is allowed to rest. The filling, perhaps, in this case, may be accomplished in six or seven minutes. It is allowed to rest, and the same operation is performed in the other tanks. I will now show you the nature of the precipitation: this is sewage matter from Dowgate Dock, containing about one in 600 of solid matter. This is the milk of lime, of which I can only now guess at the proportionate quantity. You will see the chemical action going on; but in this case it is provided, that it shall be agitated in a state of sewage, and that the lime shall enter it in a state of agitation, and this agitation is kept up for six or seven minutes, during the filling of the tank. I will therefore beg to agitate it now, and then suffer it to rest. In one hour the process is completed; the water is run off, and the tank is ready for a second charge; the charges of water are going on, the process being repeated from time to time. When the second charge comes down into the first tank, there will be a quantity of air, because the tanks are closely covered, and no escape into the atmosphere can be made; but as the filling goes on, and the air is expelled from the tanks, it passes up a tube placed in each tank for the purpose, and passes by another tube into a condensing chamber, which is constructed according to the model. There are four layers or trays, on which may be deposited coke broken into sizes (to use a familiar illustration) that we would break knobs of sugar into for our tea, and saturated with muriatic or hydro-chloric acid; this apparatus affords a tortuous or convoluted passage.

1764. That resembles a gas purifier?—Yes, during its passage over this matter the ammonia which may have been in combination with the air in the tank is abstracted, and there condensed, so that no ammonia passes into the atmosphere; but the common air is led off by a passage into the chimney, and escapes. I will illustrate that by showing you: I have in this bottle hydrochloric acid gas, and in the other ammonia. These two substances cannot be brought together without a combination at once ensuing: white fumes are formed, and the matter is arrested in its course; it is deprived of those wings which it had before, and by which it could fly off into the atmosphere, and it is there

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there reduced to the condition of sal ammoniac, which bears a certain commercial value. The matter of precipitation, or the precipitation going on again for several successive times, say 10 or 12, it is necessary now to obtain the pulpy matter from the bottom. It is not, perhaps, so clear as it would be after an hour; but it is now a very different matter from what it originally was. We have got by far the largest quantity of feculent matter down, and it is in that condition that it will never offend the nasal organs again. We can make it perfectly clear; I do not know that it will be necessary to do so in this wholesale manner. I think this is as much as the most fastidious could desire, when it is intended to be turned into the river. If a supply for the use of the inhabitants is required, we should use this process, which is passing it through a charcoal filter. The whole process takes an hour; therefore due allowance will be made for the rapid way we are passing it. The pulp now requires to be removed; a valve is drawn at the bottom; here is the passage on an incline, which permits it to flow down into a lower receptacle, from which it is raised by a Jacob's ladder, and turned into this upper receptacle. It is now quite in a harmless state. From the Jacob's ladder it is removed by means of a hollow cylinder capable of some degree of exhaustion; this exhaustion is here performed by an air-pump, but where we could get a sufficient fall from the cylinder, to have a long tube to carry it off, we should be able to make the water which passes through into the cylinder perform the exhaustion, simply by the force with which it falls, and will require no artificial means of exhaustion. As the cylinder revolves, it brings up with it a thin film of the sewage matter, very much like that which is brought up from the pulp of a paper-mill. It is, perhaps, twice as thick as brown paper; in this condition it is taken off by what is technically called the doctor, or scraper, which removes it immediately to a series of endless cloths, or bands, which are put in motion by the machinery; these revolve at a given rate, and the sewage performs its revolution along them, or rather round them, and when it comes to the end, it drops off, and is found on the cloth going in the other direction; so it performs its course until it ultimately finds its way into a hopper, from whence it may be transferred into bags in a marketable state.

1765. Is there any artificial heat applied to that process?—There is; this is a closed chamber, through which a current of air is drawn among the cloths, at a temperature of 120; it will pass out by any convenient apertures at the top, or may be conducted into the chimney shaft, or through the condensing chamber, if there should prove to be the least necessity, which I do not believe there will; for the air then is quite in an unobjectionable condition. The hot air is prepared by means of a fan, and driven through a furnace, where it is brought to the required temperature.

1766. Now this process you have practically tried in the way you have described?—Yes.

1767. Have you found, notwithstanding the complication which to the unlearned attends it, it is easy and simple in operation?—I have.

1768. Is it an expensive process?—It is not.

1769. When you speak of not being expensive, I presume you mean that it does not exceed the value of the article produced?—Certainly.

1770. What is it, compared with the value of the article produced, according to your experience hitherto?—As far as my experience has led me to conclusion hitherto, it does not come up to one-half of the value of the article.

1771. Have you put 50 per cent. for working expenses?—Yes.

1772. What price have you got in cases where you have tried it, Cardiff particularly, for the manure so produced?—At Cardiff the manure fetches 3*l.* per ton; not a very large number of tons have been made; but, as far as it has gone, it has fetched 3*l.* per ton, and has never been sold under that price, and has given satisfaction at that price.

1773. When that issues from the machinery, is it in a state of a dry powder?—It is.

1774. Similar to guano, or any other artificial manure?—Yes. There is one peculiarity in this powder, that it could not be very easily adulterated, or a similar thing fabricated without some considerable expense. As it passes over the cylinder, it is strongly indented with the fabric of the wire cloth with which the cylinder is covered; when it comes to the end, it falls over, and presents a new surface, so that there is a new surface for the action of the heated air; and being

being considerably indented, it soon begins to fall in pieces, and crumble up into a powder without any crushing or subsequent operation; it crumbles up into such powder as you see here (*producing a bottle*). There is a second precipitation that takes place in about a quarter of an hour after the first; and that is owing, I believe, to a small quantity of urea remaining in the water. Urea is an extremely soluble substance, and one that we cannot separate; it passes through the water, but the lime acts on it as a decomposing agent, accompanying the urea, it throws off a small amount of ammonia, which, by the operation of our condensing apparatus, is thrown into it by the vacuum which is formed; it throws off a small quantity of ammonia, and the carbonic acid (the other component of the urea) uniting with the lime, goes down in the form of carbonate of lime. I now beg your examination of that; which will give you an idea of what we can do with water. This is in a most filthy condition at the present moment.

1775. In your experience, what have you found the produce of sewage water to be?—I can give you an analysis or two on the subject, made from the real products.

1776. I want the bulk of produce that a given quantity of sewage water will yield?—I think that that must be reckoned, as has just been stated, at 1 in about 800; I think that would be as near, in my judgment, as we can calculate it; for the quantity of sewage matter contained in sewage water at different times is so various, that it is impossible to find the absolute estimate for it.

1777. You have known it to be as much as 1 in 500 and 1 in 800?—I have known it to be as great as 1 in 310 on an average of three sewers taken for a week. I beg to read a note I have here, which will throw some light on the subject. "Observations made on the Grosvenor, Horseferry and Wood-street Sewers, as to quantity of manure obtainable therefrom. 1847: a Week.—Six days were employed upon those three sewers, from 22d February to 27th; the time was near low water; the quantity operated upon 2,000 gallons; the results were very various, according to the time of day, being highest in the afternoon, the greatest quantity being 10 parts in 2,000, or 1 in 200; the smallest 3 ½ in 2,000, or 1 in 570; the average, 1 in 310." I have likewise the result of three sewers taken within the last week. "On Saturday evening, June 4th, at half-past six in the evening, the water from the Effra was collected for the purpose of ascertaining this, and gave 1 in 1,455. On Monday, at half-past 10, the River Fleet, the Fleet Ditch, as it is called, gave 1 in 762; and as soon after as the collector could go from the one to the other, the Dowgate Dock gave 1 in 665." I say that neither of these would give an absolutely fair average of the quantity of sewage. On Saturday evening it was a very unfair time to collect anything like an average amount from any sewer, because manufactories had stopped progress, and the household cleaning had been, I presume, or nearly all, accomplished; therefore there will be very little coming down but clear water. The same might be said of the city on Monday; many of the citizens had left town; they had not commenced their business, and the products of life were not flowing in their full stream.

1778. Now, supposing the sewage of the Metropolis equal to 100 millions of tons, what, according to your estimate, would be the produce of dry manure from that?—I think the produce of dry manure would exceed 100,000 tons a year.

1779. Taking it at the figure you have stated, it would work out to 125,000 tons?—Perhaps it might; it would be more than 100,000.

1780. At 3 *l.* a ton, that would be 375,000 *l.*?—Yes.

1781. From which you would have to deduct 50 per cent., the cost of production?—Certainly.

1782. That would leave 187,500 *l.*?—Yes.

1783. Now, where you have actually practised this process at Cardiff, has it been conducted by scientific persons?—It has not.

1784. Have the inmates of the gaol carried on the ordinary operations?—They have; I should say that they were carried on under the supervision of the governor of the gaol, who is a gentleman of intelligence; but I am not aware that he is a gentleman who has devoted his time to scientific attainments; but the operations themselves have been entrusted to persons for the most part, I am sure, quite ignorant of the scientific nature of those operations which they carried on.

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1785. The only material point, I believe, is to proportion the quantity of milk of lime with some degree of accuracy to the quantity of sewage water?—Yes.

1786. And that at once is fixed by the size of your tanks?—And the quantity of sewage. It would require a little attention.

1787. *Committee.*] We thought you said the quantity of sewage is varying?—Yes; it must be proportioned to the size of the tank, and the quantity of the sewage flowing at that time.

1788. We understand that, when you once ascertain the size of the tanks?—Yes.

1789. Mr. *Hope.*] Do you require that every different character of sewage water should be met with a different application of milk of lime?—No; because in dry weather you will have less water, and more sewage; time of day will make a difference, but experience would soon point out these facts, and with sufficient accuracy might this plan be carried on.

1790. Of course that state of matters occurs at Cardiff, as at anywhere else, the nature of the sewage and the variation of sewage in those hours?—Not exactly in Cardiff. They flush out in the evening, and the water is carried into the receiving tank, where it remains till a convenient time occurs for pumping; they then pump the water, and it is allowed to rest till another convenient opportunity is allowed for further treatment. The work is small, the number of inmates do not exceed 100; but it is quite sufficient to test the character of the operation for the largest work that can be conceived.

1791. *Committee.*] For this number of persons, namely 100, what are the size of your tanks?—The tanks are five feet square, by seven and a half feet deep.

1792. How many tanks have you?—Two; they are worked alternately right and left. It is quite evident that if they had ten times the quantity of sewage, they might work it in these tanks.

1793. The number of tanks is to be proportioned to the amount of sewage water brought down?—To the amount of sewage water flowing down.

1794. Has there been any report made by the governor of that gaol as to the supposed rate of remuneration which that manufacture has brought forward?—

Mr. *Hope.*] He is coming before this Committee.

1795. To the *Witness.*] With regard to the proportion of the milk of lime and the sewage matter, I suppose that is important as a question of economy?—Precisely.

1796. You cannot put too much milk of lime in?—It will do no harm whatever.

1797. It will be merely waste of power?—Yes.

1798. And therefore waste of money?—Yes.

Cross-examined by Mr. Serjeant *Wrangham.*

1799. First of all, I ask whether your apparatus there cannot be worked at the mouth of each sewer, without any tunnelled sewer for the purpose?—There is no doubt it could be so worked; but I think in the city of London land is so exceedingly expensive—so I was informed, however, by the chief surveyor to the City Commissioners—that land is so exceedingly valuable there, that it would be difficult to get sites for working it; otherwise there would be no difficulty in the working it.

1800. I mean the produce of sewage matter in any one main sewer in London would largely exceed the quantity with which you have been dealing at Cardiff?—Yes.

1801. As to Cardiff, have your experiments been confined to the sewage matter from the gaol?—Yes.

1802. Nothing else?—Yes.

1803. You have not had to deal with the heterogeneous matter that runs down the sewers of a large city?—Not in the calculation I have made from Cardiff. But I have had experience; and I have had about nine years' experience of the nature of the London sewage, and during the whole of that time my attention has never slept, but it has been on the stretch to investigate the nature of the London sewage, and find out all the properties.

1804. You

1804. You can tell me that London sewage matter is not the same thing as the sewage derived from a single building, the gaol?—Nearly so; we have certainly not the products of manufactories, but the products of life must be almost identical in all cases.

1805. There is the soap and water and the fœcal matter from cookery, and so forth, that does not represent the nature of the contents of the sewers of a great town running through the streets; they must receive a great deal besides that?—It does not materially differ from it in its properties, as analysis will show.

1806. Well now, with what quantity of sewage water per day have your experiments at Cardiff dealt?—That I am unable to answer with accuracy; but I should suppose sometimes with two tanks full, the capacity of the tanks being five by seven and a half.

1807. Put that into gallons for us, or cubic feet?—In round numbers they hold 187 cubic feet each.

1808. Eleven hundred gallons?—Yes.

1809. You are aware of the quantity of sewage water that is anticipated in these large reservoirs from the tunnel?—Sixty million gallons.

1810. That will be 10,000,000 cubic feet?—Yes.

1811. Now, your experiments have been limited as the maximum to 1,100 gallons?—Yes.

1812. Or about 187 cubic feet?—Yes; twice 187.

1813. Sixty millions of gallons; now about 1-800th part is solid matter?—Yes.

1814. Sometimes 500 and sometimes 310?—I have found it so, and speak of this as an average.

1815. Have you ever found it less than 1 in 800?—I found the average much less some years ago; but there has been an increased quantity of water used for sanitary purposes; there has been a more liberal supply from the water companies; therefore there is more water, and less solid matter in proportion.

1816. Have you ever found the solid matter bearing to the whole quantity a less proportion than 1 in 800?—Yes.

1817. To what extent?—I should say to the extent of 1 in 600.

1818. That is a larger proportion, not a smaller?—Yes; I am speaking of a larger proportion of solid matter.

1819. I am asking the smaller proportion?—No; I have never known it smaller.

1820. You have known it larger?—Yes.

1821. How came you to make that the average, if you have known it 1 in 300, and never less than 1 in 800; how is that the average?—Because, when I have known it produce a larger average, it has been in years that are past, a particular average of sewers, where there has been no water-shed.

1822. The average you get by striking a mean between two extremes, I presume?—Yes.

1823. Now you have given me an extreme one way, 1 in 310, and 1 in 500, and 1 in 600, and you cannot go above 1 in 800?—One in 310 is in particular circumstances.

1824. One in 500 you have known it?—Yes.

1825. One in 600 you have known it?—Yes.

1826. But never lower than 1 in 800?—At particular sewers I have known it as high as 1 in 1,400.

1827. Are we to understand that you cnosider 1 in 800 not as a minimum of solid matter, but as the average?—As an average; I consider it an average; I have no very accurate means; but that, to the best of my means, is what I consider to be the average of the supply.

1828. Now tell me, how long a period does it take from the time when the sewage-water comes into your reservoir to the time when you turn out this powdered guano?—The whole may be accomplished, as I before stated, in one hour; perfectly accomplished, as I think I have demonstrated.

1829. Till it becomes dry, and you turn it out; till you turn the pancake out, as my friend called it?—Certainly another hour will accomplish that. I am speaking of this inlet and its flow, and its precipitation is one hour; in less than another it may have been past the cloths, and fit for the market.

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1830. Then the whole operation we will take to be two hours, according to your calculation. I suppose the size of your apparatus must depend altogether on the quantity you have to deal with?—Precisely.

1831. Have you ever calculated what space would be covered by your reservoirs for 60,000,000 gallons a day?—I am not particularly up in the engineering parts of the business; I have confined my attention more particularly to the operation itself, and I therefore leave it as a matter that does not particularly concern me, but which the engineers have to provide for, satisfied that if sufficient provision is made, all the operations can be carried on efficiently.

1832. Suppose you have space enough for it, you have no doubt it will hold the 60,000,000 gallons?—No doubt.

1833. I think we may agree with you so far. Now you say 1 in 800 of solid matter; have you ever calculated what that would be in tons, in 60,000,000 gallons; about 350 tons, would it not be?—I have not the calculation.

1834. A gallon weighs 10 pounds; that would be 600,000,000 pounds; and divide that by 800, that would give you 750,000?—Seven hundred and fifty thousand; if that be divided by 2,240, it would give you the number of tons.

1835. That would be about 350 tons?—Per day; it would be rather more than 334 tons per day.

1836. It is exactly 350, is it not. Now you take the lime; the quantity of that varies from 15 to 25 per cent.?—Under extreme circumstances you may take 25 per cent.

1837. Take the mean 20 per cent.; that would be one-fifth?—Yes.

1838. Taking it 350 tons, the solid sewage matter there would be 420 tons a day?—Yes.

1839. I think you say 3*l.* a ton is the value of it?—£. 3 it fetches at Cardiff; whether it will fetch the price when there is a plentiful supply, I am unable to say.

1840. That would be 1,260 *l.* a day?—Yes.

1841. Or, according to your calculation, in 365 days, or one year, 460,000 *l.*?—Yes.

1842. Now, I understand you, that the cost of the operation is about 50 per cent. on the produce?—Yes.

1843. Dividing that by two, would leave you 230,000*l.* a year?—Yes.

1844. A profitable business?—I hope it may prove so.

1845. Do you think it would want any rate in aid, any guarantee?—I do not think it will eventually.

1846. Putting it at four per cent., which is putting it high, there would be 40,000*l.* to be deducted; that would leave you 190,000*l.* profit; that would be so?—I believe so.

1847. Now, then, to revert again to the operation; as I understand you, the effect of it is to spread out the solid matter into a thin layer, about twice as thick as brown paper?—Yes.

1848. Should I be wrong in taking that as about the 16th of an inch?—No.

1849. Now, I believe, that 420 tons would give about 12,000 cubic feet?—I am not prepared to say; a large amount of space.

1850. There is about 30 cubic feet to a ton of this matter?—Yes.

1851. What I want to know is, have you ever taken into your calculation the space that 12,000 cubic feet, reduced to a layer of the thickness of the 16th part of an inch, would cover; what superficial area?—Yes, I can tell you, if we take an apparatus like that, 64 feet long.

1852. Just answer my question first; give any explanation afterwards; have you ever calculated what 12,000 cubic feet extended, instead of being in cubic shape, to a layer only one-sixteenth of an inch thick, what superficial area would 12,000 cubic feet cover?—I have not.

1853. Within a square mile or two?—It must be borne in mind that the matter will not all cover the space at one time; it will be continually spinning out.

1854. We must go by steps: are you prepared to say that that 12,000 cubic feet, reduced into a layer of the thickness of the 16th of an inch, would not cover 50 square miles?—I am not prepared to say it, because I have not made the calculation.

1855. Can you tell us the space covered by 100 cubic feet?—I was about to say what quantity of manure an apparatus of this kind would dry in a specified time;

time; if I take an apparatus 64 feet in length and 6 feet in width, and having 10 convolutions, it will dry 59 tons per 24 hours.

1856. I presume, in order to arrive at that conclusion, you have calculated how much a cubic foot would cover?—I have.

1857. How much is it?—I really forget at the present time.

1858. That is unlucky, because it disables one from testing it; cannot you give us any notion of the superficial area that a cubic foot would cover, reduced to the thickness of the 16th of an inch?—One hundred and ninety-two square feet.

1859. Now let us go on; 1,000 cubic feet would be 192,000 square feet?—Yes.

1860. You say that the whole operation takes two hours from beginning to end?—Yes.

1861. Therefore we will assume that every two hours you change?—Not so.

1862. Is this to go on all the 24 hours?—This will go on day and night.

1863. I am giving you exactly your own view of it, changing it 12 times?—Not so; it will change every moment, because every moment of time it will be passing several feet of water, and other water will accumulate.

1864. At the same time, it will take two hours before each cubic foot of sewage water is turned into a corresponding quantity of dry stuff?—I speak at the maximum; in reckoning that, I am allowing myself plenty of margin; I say it will be done within two hours.

1865. In making the calculation we must have something, and I take what you have given me; now, can you tell me the superficial area of acres of 192,000 square feet?—I cannot.

1866. Would it be about four or five acres?—I am not prepared to enter on this part; it belongs rather to the engineering; I have done nothing in it. I have attended to the manipulation of these matters, and the certainty with which they have been accomplished. I beg to make one remark, that the manure will never be spread over one surface, but will be distributed over ten.

1867. Did you give this evidence, or evidence of the same kind, and explain the same scheme before the Committee in 1846?—I explained the principle at the time.

1868. And with drawings?—That was a drawing not intended for any particular place, but merely to give the same principle.

1869. That model is to give the principle?—That was intended for a town; calculated for a town. The other was to give the chemical principles of the thing.

1870. You put in a report, then?—Yes, I did.

1871. Was it before the Select Committee on Metropolitan Sewage Manure?—It was.

Cross-examined by Mr. *J. Clerk.*

1872. How many tons did you manufacture at Cardiff of this manure?—I am unable to say. The governor of Cardiff gaol will tell you.

1873. What is the state of dilution of the sewage water at Cardiff?—I cannot say from my own experience, but I believe it is somewhere about 1 in 300, probably.

1874. That contains the fæcal matter of the gaol?—Yes.

1875. Your milk of lime is an alkali?—Yes, it is an alkali.

1876. Have you considered that in the town of London there is a vast amount of alkaline matters in the matter of the sewage?—The sewage matter is neutral.

1877. Are there no alkaline matters in the sewage of London?—Yes; they are counterbalanced by acids, and the sewage is neutral.

1878. Are there not alkaline matters in suspension in the sewage of London?—There are alkaline matters to be found; there is abundance of table salt and also salts of potash.

1879. Those would not be acted on by your milk of lime, which is itself an alkali?—Only to a small degree.

1880. So far as they are natural salts?—They would be carried down by a sort of entanglement; they are always found in analysis in this sewage matter.

1881. Have you considered, when you mention a certain price as the value of this manufactured product, what amount of road drift there will be in the sewage matter that will be raised into your tanks?—The largest amount that

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have ever found on any occasion, I think, has been 14 per cent. of siliceous matter.

1882. Where was that?—I am not able to say; I have distinctly in my recollection that is the largest amount I have found.

1883. In order to ascertain what will be the quantity of siliceous or other matter at the end of a large sewer receiving the whole sewage of London, it is necessary to know where you take that from?—I think it was taken from the Horseferry Road Sewer.

1884. *Committee.*] Whereabouts is that?—At the end of Millbank-street.

1885. Then taking that quantity of 60,000,000 gallons, and that proportion which you gave of road drift that you found in the Horseferry Sewer, and assuming that to be the quantity throughout, what proportion of road drift would it give to be raised at the end of the sewer?—You will be pleased to observe that that road drift is raised with the matter; it is not a something which subsides when in an agitated state; the whole of it comes up. A portion of this matter is soluble, and would aid the production of vegetation, it being a very excellent manure itself, forming the outward covering for the cereal plants.

1886. That is, 45 tons of drift would be about the proportion to the 330 tons of solid manure you are to obtain per day?—Possibly.

1887. Is it necessary for the whole of the reservoirs to be arched and covered in, for the purpose of preserving the ammonia?—It would.

Re-examined by Mr. *Hodges.*

1888. With reference to the carrying on of this manufacture, the works will be going on night and day?—Yes.

1889. And this dust or manure would be continually poured out; as it was turned off, it would be put into sacks?—Yes.

1890. You have been asked what is the surface that would be required; if you were at a paper machine working all day it would not require a large acreage?—Undoubtedly not.

1891. Is not that a just and sensible mode of acquiring the quantity, as in this case?—I think it would be.

1892. Have you any doubt that the works can be carried on better on a larger scale than on a smaller one?—Undoubtedly.

1893. This amount of road drift which we have heard of as being 14 per cent. is very high?—In the extreme.

1894. Would that be anything like the proportion?—I think there would be seven or eight per cent. of it which would be soluble; it would be precipitated, and form part of the manure.

1895. Would not the effect of a greater quantity of drift be this, that the manure would be less valuable on that account?—Precisely.

1896. It could be manufactured just as well if the quantity were greater as if it were smaller?—Just so.

1897. With respect to the suggestion that your apparatus could be put at the mouth of every sewer, did you investigate that, whether it was possible to put up in a city like London?—It may be put up at a great expense; no inconvenience to the inhabitants, but a monetary inconvenience.

1898. Therefore you think the other is the preferable plan, carrying it down to the verge of population, and turning it into manure?—No doubt of it.

Mr. *Webster* stated that he did not wish to cross-examine at present, as he thought some arrangement would be made, but he trusted he should be at liberty to appear on the clauses at the proper time.

Examined by the *Committee.*

1899. When did you take out your patent?—It was sealed on the 28th April 1846.

1900. And since that time you have never persuaded any one to try it, except the Cardiff gaol?—It has been tried, in a measure.

1901. Where?—It was tried at Puddle Dock, and succeeded admirably as far as the arrangements went; but it has been broken up, owing to other circumstances. It was in operation for, I should think, speaking with a rough remembrance, two years.

1902. When

1902. When you say that it succeeded admirably, and was on trial for two years at Puddle Dock, can you tell what quantity of manure was produced?—I cannot, for I have had no control over it.

1903. At any time, can you tell what was produced?—I cannot; I should think there must have been produced a ton and a half per day.

1904. What sewer was brought there to try it on?—Puddle Dock Sewer.

1905. What quantity of sewage comes down that sewer?—That I am unable to say; I had no control of the works.

1906. Did you not, taking an interest in your patent, go to visit these works?—I did, frequently.

1907. Have you any notion on what amount of sewage the experiment has been tried?—I can tell the size of the tanks, and what their capacity.

1908. Very well?—They had three tanks a cube of 10 feet, and one 16; that was the number of tanks they had.

1909. And how much manure did it make in a day?—A ton and a half; as they took it from a high level (they were permitted by the Commissioners of Sewers to take the matter from a high level, from the level of Ludgate-hill, through which they drove the tunnel). Sometimes this water failed them; they had not a sufficient quantity for their works, and at other times they had more than they could dispose of.

1910. Do you mean that the tanks were not large enough?—The tanks were not large enough for it at times, because all the flood-water came in through them.

1911. And they had no means of shutting out the flood-water?—They had an overflow then.

1912. Did it prevent the works at all?—Not at all; there was a bridge put across the sewer, from which they had a supply pipe.

1913. Can you tell at all for any consecutive time what quantity they made per day?—I never had the opportunity of ascertaining what quantity was made per day.

1914. Were you excluded from the works?—Partly so.

1915. Did you quarrel with the people when they set it up?—There had been an arrangement that I should superintend them; but I declined to do so. They were carrying on experiments which neither met my sanction nor exactly agreed with my patent, and I was partly excluded from the works.

1916. Did you ascertain what they sold the manure for that was produced?—I do not know what became of the manure; I know nothing of it.

1917. You might have heard from some one else?—I had many samples of the manure, and knew it was exceedingly good; beyond that I did not know; I was not in the confidence of the party who held it.

1918. When did this Puddle Dock experiment cease?—That I am not able to inform the Committee of.

1919. It did, for some reason or other, fail?—Not from the manufacture of sewage, but other causes connected with the proprietor.

1920. Were they commercial causes?—I judge so.

1921. You think it was not from the inability to sell his manure for sufficient money?—No, I think not.

1922. Is there any other place where your scheme has been tried?—One; there was a similar scheme to that in Puddle Dock I superintended myself for four months, at Northumberland Wharf.

1923. There a large sewer comes down?—There a large sewer comes down, but they were only able to take small portions of it; we had three cylinders six feet high and 18 inches in diameter; they were stone pipes, in fact, put one on the other, having a stone bottom.

1924. Did you undertake this experiment at the Northumberland Sewer in order to convince the Commissioners of Sewers of the advantage of this scheme?—I did, and they reported favourably upon it.

1925. Have you got their report?—I have it not here.

1926. They reported favourably on the scheme?—They did.

1927. After four months' trial?—Yes.

1928. Now, can you say there, where you superintended yourself, what amount of manure was produced in a day?—No, I cannot, because we did not work it off at once, and the quantity we produced one day was mixed with that of another. We had but one man, and that is a portion we produce (*producing a sample*).

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sample). It has been in that state nearly five years, and it is now in all its integrity.

1929. How did it sell?—We did not try to sell it.

1930. Did you try any agricultural experiment with it?—Yes; it was distributed among different gentlemen.

1931. Did you get any report upon it?—We had a report at that time, very favourable indeed; we had one from Mr. Reginald Cocks, banker, of Charing-cross; with this matter he raised some enormous gigantic celery, which he said was a great luxury; in fact, it had the right nutty flavour; cabbages he also raised to a very great weight.

1932. If this succeeded so well, why was it given up at the Northumberland Sewer after four months?—We had merely permission to use a stable for that purpose, to try it as an experiment; it was not intended to be perpetual.

1933. Then you say it was satisfactory?—It was to all who saw it. Dr. Buckland viewed the works; he had been a great opponent of the scheme, but he retired perfectly satisfied with the healthiness of the plan, and the products.

1934. Having shown its perfect success there, what year was that in?—It was five years ago.

1935. Since that, has there been no experiment with it, as it was so successful five years ago?—No; except at the Puddle Dock and at Cardiff.

1936. When was it begun at Cardiff?—Four years ago come October; it has been in daily operation ever since.

1937. That is on a much smaller scale than it would have been at the Northumberland-street Sewer?—Much larger.

1938. If you take the whole that comes down to Northumberland-street Sewer, it would be much larger?—Yes; there was an application made to the Commissioners of Sewers for the sewer at Essex-street, but they could only grant it for one year, and that would not justify the outlay for works.

1939. Did you try to set it up at the mouths of any of the other sewers?—At no other sewers.

1940. Who made that application for the Essex-street Sewer?—I did, in conjunction with Mr. Moffat, of Spring-gardens.

1941. Do you know anything of the system that has been tried at Leicester, or commenced at Leicester?—I do not; I have heard of such a system.

1942. But you know nothing of the details?—No.

1943. Do you know whether they are interfering at all with your patent?—I do not know; I have had intimations to that effect, but I am told it is useless for me to go to Leicester, because I should not be admitted on the works.

1944. What was the expense of putting up these works at Cardiff?—£. 200.

1945. Have you had any explanation with the town of Cardiff?—I have applied to operate in towns; and among others, I have applied to the town of Cardiff, which contains a population of 20,000 inhabitants.

1946. Do the present company propose to use your patent?—Yes; it is under consideration at the present moment. Besides the town of Cardiff, I have applied likewise to the town of Croydon. I have had an interview with the Board of Health, and have shown them this process. I have received water from Croydon, for the purpose of trying my scheme on it. This was done on the 13th January in the present year. That is the cleansed matter; the other is the water from the mouth of the sewer (*producing two bottles*).

1947. You applied to the Board of Health to be allowed to try that at Croydon?—I applied to the Croydon local Board of Health in the first place, offering them my scheme as the remedy for the evils which then existed; there was a great fever in the town; they said they were not prepared to become manufacturers. I then made an application to be allowed to have this matter for the purification of it for the benefit that I should do to the town. I applied to have this matter placed at my disposal, and that is under consideration at the present moment.

1948. When did you make this application?—About Christmas.

1949. Was that the first application you made to Croydon?—No; I think the application was made before that, but I cannot speak as to the date.

1950. But you have had no reply?—I have had two or three replies from the Board of Health, saying that the thing still remained under consideration.

1951. Have you had any answer from the Croydon Board?—I have had two

or

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or three communications from the clerk, saying that it remains under consideration.

1952. What other towns have you applied to?—I applied to the town of Warwick, and they recommended me to go to Leamington, as they were about to make a general matter of the sewage.

1953. And you did go to Leamington?—I was received exceedingly well at Leamington, but nothing has yet been done. They were desirous I should report progress if any improvement was made in any other place. Each town seems unwilling to be the first,

1954. No one likes to make the experiment?—No.

[The Witness withdrew.

Walter Coffin, Esq., a Member of The House; Examined by Mr. *Calvert*.

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1955. ABOUT three years ago you found that the sewage matter from Cardiff gaol created a great nuisance to the neighbourhood?—Quite so.

1956. And you recommended the treatment by lime, as patented by Mr. Higgs?—I did.

1957. Did the magistrates adopt that recommendation?—Yes.

1958. Are you one of the magistrates?—I am.

1959. Were works put up in the gaol under Mr. Higgs' superintendence?—They were.

1960. By those works was the sewage water of the whole of the establishment conducted into a reservoir?—It was.

1961. Was it pumped out into a tank?—It was.

1962. By that mixture was the mud and the noxious matters precipitated?—They were.

1963. And the water clarified?—Quite so.

1964. Has this practice now been in operation three years?—About three years and a half.

1965. Is the working of it by the prisoners, under the superintendence of the governor of the gaol?—It is.

1966. Has the effect been satisfactory?—Entirely so.

1967. The water now discharged from the gaol is clear?—Quite clear.

1968. Looks like spring water?—Exactly.

1969. Is it fit to drink?—I should think its appearance would make it fit to drink; but knowing where it came from, one would not like to drink it.

1970. In short, has the nuisance complained of been entirely removed?—Entirely.

1971. And, in your opinion, has the object been satisfactorily attained?—No doubt of it.

1972. The mud deposited is dried?—Yes.

1973. Is it sold for manure?—Yes, it has been sold to several farmers in the neighbourhood.

1974. During the last three years?—It has.

1975. What price has it fetched?—I am informed it has fetched 3*l.* a ton.

1976. Have the works been done by the prisoners?—Yes.

1977. So that with respect to the pecuniary expense you could not form any criterion?—None whatever.

1978. But as a mode of rendering noxious sewer matter clear and harmless, you consider the process quite successful?—No doubt.

1979. Should you recommend the adoption of it elsewhere, having tried it in your own town?—Certainly I should.

Cross-examined by Mr. *J. Clerk*.

1980. How many tons have been produced in these three years at the gaol of Cardiff?—The governor of the gaol will answer that; I could not tell you; but in the absence of all convenient machinery at Cardiff, the great object being to remedy a nuisance created by the foul sewage that went from the gaol, we found it very difficult to dry as much as we could make, therefore the quantity we can sell is comparatively small. The stove we have for drying it and moulding it, and the mode of moulding it into small pieces, makes it rather a complex and difficult operation there. But the view of the magistrates at the sessions was to

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remove an evil, which caused the cholera at Cardiff to a very great extent, and it has quite succeeded.

1981. Then what you speak to is the success of this process to render the matter innoxious; as to its commercial value, you have not tried it?—I have not tried it on land of my own, but I have asked farmers who have tried it, who have come again for additional quantities. I conceive it must have a certain commercial value; how great that is I am not prepared to say.

Re-examined by Mr. *Calvert*.

1982. Do you know for what crop it has been tried?—For wheat; but the governor of the gaol will be able to tell you more about that.

1983. *Committee.*] Why, if it has succeeded so well at the gaol, has not the town of Cardiff tried it?—I am one of the Board of Health to the town of Cardiff, and my first acquaintance arose with this matter from being mayor of Cardiff when drainage was first talked off; ever since that time we have been engaged in a continual dispute which is best, pipe or brick drainage, and we have never got out of that. We have just succeeded, at last, in referring the matter to an engineer from London, Mr. Hawkshaw, and I hope he will consider this matter in reference to the drainage of the town. We are most particularly situated at Cardiff. It is on a great flat, and the tide of the Severn rises about 45 feet spring tides, and we have scarcely any fall at all there. The Board of Health seem to have an idea that nothing but liquid manure will do; that the application of the sewage is only good in a liquid state; and we have been in the most doubtful and disagreeable state, and we are terribly apprehensive of the cholera coming again, which killed 700 when it was last there. The drainage is very bad at Cardiff indeed.

1984. You were prevented at Cardiff adopting the scheme on account of this difference of opinion between the pipe and the brick drain?—Yes. The Board of Health sent one of their inspectors down, and he gave us a plan, and that comprehended very extensive engines for pumping up the sewage, and the people were frightened at that; and no town can adopt any system of drainage that the Board of Health will not approve of, because they will not certify that they shall borrow money; and in that state it has been ever since.

[Adjourned till To-morrow, at One o'clock.

Jovis, 9° die Junii, 1853.

LORD SEYMOUR, IN THE CHAIR.

Mr. *John Pateman Woods*, called in; and Examined by Mr. *Hodges*.

Mr. *J. B. Woods.*

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1985. YOU have been Governor of the county gaol at Cardiff for some time?—I have.

1986. Some three or four years ago were there some works put up there for the purifying of the sewage of the gaol?—There were.

1987. When were those works erected?—I think they have been erected about three years and a half, as near as I can recollect.

1988. What was the cost of the works put up?—About 200 *l.*

1989. They were put up by order of the magistrates, I believe?—They were.

1990. Do the works consist of a pumping apparatus, two working tanks, and a lime tank, and also a mixing tank?—Yes, and a reservoir.

1991. What is the method of working the apparatus?—The sewage matter is worked up into the mixing tank.

1992. Do you first collect all the sewage water into the cistern?—It all runs from the gaol into the sewage tank.

1993. Or cistern?—Or cistern; from which it is pumped into the mixing tank; the milk of lime in the tank is then at work, and the lime falls upon the sewage as it is so pumped.

1994. Then

1994. Then in the mixing tank you mix the sewage water with milk of lime in a certain proportion?—Yes.

1995. And after the lime has been mixed with the sewage water what becomes of it then?—It drops into the operating tank.

1996. Is that the subsiding tank?—Yes.

1997. After the liquid is in the subsiding tank, what is the next operation?—We generally pump it up of an evening, and leave it till the following evening; we then let the water pass off from a tap into the common drains.

1998. In what state is that water that you take off?—Quite clear.

1999. Is it free from smell?—Free from all unpleasant odour.

2000. And no nuisance has been found to arise from that water?—Not the slightest complaint.

2001. You say the practice is to allow it to stand all night; can you say whether it is at all necessary that there should be that long period of time for its subsidence?—Not at all.

2002. You do it for convenience?—Yes; it may be let off in half an hour; it has been nearly bright, not quite; but in an hour it is quite bright.

2003. Now, in what way do you get at that which is precipitated in this tank; how do you get at that?—We have a valve at the bottom of the operating tank, and it is let off as soon as it becomes sufficiently solid to take out in a basket, and hence it is put into a strainer with a false bottom and perforated sides, in order for it to drain.

2004. After it has been sufficiently drained, what is then done with the residuum?—When it becomes in a sufficient state to handle, it is put out in the air and dried, and moulded in the form of bricks.

2005. Do you dry that by means of artificial heat, or not?—At this time of this year it is dried by the summer heat. The air has an effect on it, and the heat is sufficient to dry it; but in the winter it is dried by artificial means.

2006. In that state it is sold?—It is.

2007. What price have you obtained for the quantity you have sold?—£. 3 per ton.

2008. When did you first commence selling it?—I think, to the best of my recollection, it was 1851.

2009. Do you find the same persons come again to purchase it?—Yes.

2010. I suppose it is purchased by farmers?—I have had reports from two farmers; in fact, I do not recollect that I have sold it to only two in the neighbourhood.

2011. Your gaol is not a very large one?—No.

2012. *Committee.*] To whom have you sold besides farmers?—Several gentlemen in the neighbourhood have had it for trial, I believe more for gardens than anything else. It has not been properly tested, only by these two farmers, that I am aware of.

2013. Mr. *Hodges.*] Have the same parties come again to purchase more?—Yes. There is a Mr. Spencer, a farmer renting a large farm under the Marquis of Bute, he had it in 1851 for turnips; in 1852 he gave me an order, I think it was for two tons, for wheat. He also gave me an order this year, but I was unable to dry it and get it properly prepared for his use in time.

2014. Have the reports you have received been favourable?—Very. Another gentleman, a very respectable farmer, renting a large farm under the Marquis of Bute, of the name of Roberts, in the neighbourhood of Cardiff, has had some to try it against guano, and his report to me was, that with an equal quantity of manure and an equal quantity of land the crop was equal.

2015. That was as contrasted with guano?—Yes; that was his report to me.

2016. What is the price of guano?—£.10 per ton, I am told, it is sold at in Cardiff.

2017. In your judgment, would you be able to maintain this price of 3*l.* per ton, from the experience you have had?—I think so, by the reports I have had.

2018. I was asking you about the number of persons confined in the gaol, I believe. The prisoners are not numerous; what is your average?—I do not exactly know, but I think it exceeds 80.

2019. Have you carried on this work by means of the prisoners?—It is superintended by one of the turnkeys, occasionally by myself, to see there is no unpleasant odour from it; and the work is done by the prisoners.

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2020. You are not able to give us any account of the cost of labour?—No.

2021. Have you kept no account?—No.

2022. *Committee.*] How much per year is produced?—Not above three or four ton per year.

2023. Mr. *Hodges.*] And you say there are about 80 persons in the gaol on an average?—Yes.

2024. Does any nuisance arise from the manufacture whilst the works are in operation; any bad smell?—Not the slightest, that I am aware of; what we call the operating tanks are shut close down. There is a tube inserted into each tank, which goes through into the drying-room, and passes into a condensing apparatus, which is supplied with three drawers dressed with peat charcoal and muriatic acid, and I believe it condenses all ammoniacal vapours.

2025. *Committee.*] How near are the works to the gaol?—Close to the wall.

2026. And you have frequently visited these works?—Generally; I cannot say every day, but very frequently.

2027. And you never found any unpleasant odour?—Yes, I have; but that has been caused by not having a sufficient quantity of lime, perhaps an accident to one of the pipes, being stopped to prevent the effluvia escaping; a prisoner will sometimes do the thing for mischief.

2028. If lime is not supplied in proportion to the manure, then there is a bad effluvia?—Yes, I think there is; I have remedied it by adding a little lime; sometimes the lime is not in sufficient quantity. Mine are all unwilling agents.

2029. Mr. *Hodges.*] Has that occurred frequently?—Not more than two or three times.

2030. During the whole two or three years?—No, I think not.

2031. When the work is properly going on is there any unpleasant smell then?—No, not the slightest.

2032. You have spoken of this muriatic acid; has that prevented the effluvia; have you watched the progress of the work for that purpose?—I have never attempted the scientific part of the work; but when I have had it redressed I have found the air very different.

2033. How often is the muriatic acid renewed?—Well, I should say it has not been renewed any oftener than once in six months.

2034. That muriatic acid is very easily applied?—It is.

2035. How do you do it?—I suppose not more than a pint and a half of peat charcoal, broken small, and about an ounce and a half of muriatic acid strewed over it, mixed up.

2036. Do you heat the charcoal?—No.

2037. You merely pour the muriatic acid over the charcoal?—That is all.

2038. Is there any smell from the mud deposited from the tanks after the water is drawn off?—Not if the tanks are emptied at the proper time; if they were to stay for a month or six weeks, then I have discovered a slight smell; but when they are emptied once a week there is not the slightest smell.

2039. Do you find that the manure will keep after it is dried?—For years, I should think, from what I have seen of it.

2040. Before the system was adopted at the gaol, what was the state of the sewage there; did it cause any nuisance or inconvenience to you?—Very great inconvenience to us and to the town, and in fact the greater part of the town; complaints were constantly being made; and the magistrates had several meetings on the subject, and I believe a calculation was made, and an estimate was given in, for forming a covered drain down to the sea, which would cost about 2,000 *l.*

2041. Does it lay very low, this drainage?—It lays upon a flat rather.

2042. Now since you have adopted this process have the complaints entirely ceased?—Entirely.

2043. They have not occurred at all?—I have not heard a single complaint.

2044. You have spoken of the tank in which the sewage is first collected; is that tank so constructed as to take the whole sewage of the gaol, the soapsuds and all?—For the day the surface water, the rain water, passes into what we call the water drain, the mere surface drain we should have too much water.

2045. Do all the washings from the scullery and laundry go into that?—Yes, the laundry and scullery, and all the washings of the prisoners every morning and evening.

2046. Are

2046. Are the privies also flushed by the water?—They are.

2047. How often?—Every night.

2048. I understood you to say that the water that runs away after the precipitation has taken place is quite free from any bad smell, and you find no inconvenience arises from it?—Yes.

2049. Is it perfectly clear?—Perfectly clear.

2050. You think you could sell a larger quantity of this stuff if you could produce it?—I have no doubt about it; one gentleman offered to take all I could make.

2051, *Committee.*] When did you sell to Mr. Roberts?—I think it was in 1851.

2052. Have you sold to him any more than once?—No.

2053. Has he applied more than once?—We have often been speaking about it.

2054. But you have so very little of it?—Very little of it; I cannot get it ready in time; it is all moulded by hand.

Cross-examined by Mr. *Henderson.*

2055. Does this apparatus that you have described receive all the dejections from the gaol?—Yes, all the sewage.

2056. There are 80 prisoners, and the dejections of the governor and the inhabitants are included?—Yes.

2057. What number are there?—About ten more.

2058. About ninety altogether?—Yes.

2059. Do you know what the area of the gaol is?—About two acres.

2060. Does it receive the whole of the dejections; does not any of the water that passes from the gaol pass otherwise than through the apparatus?—Yes, the rain-water, all of it.

2061. You have seen the water when it is received into the apparatus; can you tell about what proportion the solid appears to bear to the fluid part, the water to the solid?—In the reservoir?

2062. Yes, what is conducted into the reservoir?—No, I cannot.

2063. You spoke of a nuisance that there was before; was there a drain or sewer before this apparatus was put up?—There was a drain, and it emptied into a ditch, which led into a part of the town, at which time there were no buildings.

2064. The drain emptied in a ditch?—Yes.

2065. And there the matter remained until it occasioned a nuisance?—Yes.

2066. You have spoken of the sale of the produce of this apparatus; do you know whether what the apparatus produced was always sold?—I should say not more than from 10 *l.* or 11 *l.* worth in the year; I should think not.

2067. Did you not sell more than 10 *l.* or 12 *l.* worth in the year?—I should think it would not realise more than 10 *l.* or 12 *l.* in the year, all that is made.

2068. Supposing it were all sold?—Yes.

2069. The question I put to you was, whether you have been enabled to sell all that was produced?—All that we could get ready for sale. I have a great deal on hand now, which is not sufficiently dry.

2070. All that has been completed and perfected you have been able to sell?—All that has been completed in the seed-time.

2071. Is there any product which is received from the gaol which passes away which is not sold?—Not that I am aware of.

Cross-examined by Mr. *J. Clark.*

2072. How long does it take to dry?—It is quite uncertain.

2073. What is the area of your drying apparatus?—I am sure I cannot tell; the drying stove is merely a common stove, properly ventilated on the top; it would not dry in a confined place; I tried it in a confined place, and it became a kind of puddle, like stewing; it requires to have plenty of ventilation.

2074. How much are you able to dry at a time?—I suppose not more than about 20 or 30 pounds.

2075. How long will it take to dry that 20 or 30 pounds?—I cannot exactly say.

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2076. About the average, how long?—From the time it is taken out of the tank till dried and fit for the market, I should think we could not do it under three weeks or a month, not using machinery.

2077. Before it is fit for the market?—I should think so.

2078. What is the price you say you get for this?—£. 3 per ton.

Re-examined by Mr. *Hodges.*

2079. I have only one question to ask you; suppose you draw the water off in the morning, and if you set about drying immediately, how long will it take to dry the contents of the tank, supposing you wish to do it as speedily as it can be done?—That would make a difference, because it could be taken out immediately after the water is passed off; but still it is not solid enough; we have never removed it till after a week.

2080. Where has it remained a week?—In the operating tank.

2081. With the clean water drawn off?—Yes; I have known it to be in six weeks or a month.

2082. The quantity is so small, that you have to wait some time before you have a sufficient quantity to dry?—We never think of interfering with it until the solid matter interferes with the water-pipe.

2083. The quantity you get each day is small?—Yes, very small; so small, that it has surprised me.

Professor *William Allen Miller,* called; Examined by Mr. *Hodges.*

Professor *W. A. Miller.*

2084. I BELIEVE you are Professor of Chemistry at King's College, London?—Yes.

2085. Have you visited Cardiff Gaol for the purpose of inspecting the process there spoken of by the last witness?—I have.

2086. *Committee.*] When did you visit it?—In the course of last week, on the 2d or 3d of June.

2087. Were you asked to visit it with reference to giving evidence before this Committee?—I was.

2088. Mr. *Hodges.*] That was the object of your going to Cardiff, I presume?—Exactly so.

2089. We have heard that the process consists of an admixture of some milk of lime with the sewage water; did you see the process carried on there?—I did.

2090. Did you observe how long it required for the precipitation to take place?—About half an hour was the time that was allowed upon that occasion; the water was quite clear.

2091. Then at the end of half an hour the sewage water was discharged quite clear from the sewer?—The experiment occupied an hour and a half; it occupied an hour pumping, and after the pumping had ceased, it was allowed to stand half an hour, and the water was drawn off, and found to be clear.

2092. What did you see done with the mud deposited, that which was precipitated?—I did not see anything done with that particular portion that was precipitated whilst I was there.

2093. Is this process carried on in covered tanks?—Yes.

2094. What mode is adopted for getting rid of the effluvia that would arise?—There is a pipe which conveys the gases which are liberated over a vessel filled with charcoal, and moistened with muriatic acid.

2095. Did that effectually prevent any unpleasant effluvia?—There was an odour. I had not an opportunity of examining the escape of the gases from that pipe.

2096. In your judgment, was it serviceable in preventing any obnoxious effluvia from rising?—There is no doubt the effluvia was extremely reduced by the operation.

2097. I think you said you did not witness the drying process?—No; there was some in different stages of manufacture, I saw that.

2098. Did the process appear to you to be simple?—It is of the simplest kind; it could hardly be more simple; in fact, it would be very easy on a larger scale to improve it; it was rude almost.

2099. With

2099. With respect to the clear water that is discharged, was that considerably purified?—I made an examination of the proportions of organic animal matter that was contained in it, and I found about six-sevenths of the whole was thrown down by the operation, and separated.

2100. Did you observe that the water was at all offensive when it was flowing away, the clear water?—I had no opportunity of seeing it flowing over a large surface; it had an odour, though very much less offensive than before the process was applied.

2101. Do you see any reason why the process should not be carried on on a large scale, as well as on a small one?—I know nothing about the commercial value; but certainly the operations themselves are quite as practicable on a large scale as upon a small one.

2102. Do you think the results would be generally uniform, where the quantity of sewage is alike, if the proper quantity of lime is poured in?—The composition of sewage will vary so much; but in a large city, like this, there is a certain average at a certain time of day, and the composition of the sewer will vary with the quantity of the water and rain.

2103. Will any difficulty arise in putting in the proper proportion of milk of lime?—I should imagine not; it will require a certain amount of care in carrying it out. There is one thing; a little excess of lime would be of no harm or disadvantage.

2104. Has your attention been directed to a Report presented to the Commissioners of Woods and Forests with respect to the London Sewage Chemical Manure?—Yes.

2105. That is a Report by Sir Henry de la Beche and Dr. Lyon Playfair, and two or three other chemists?—Yes.

2106. *Committee.*] What is the date of the Report?—I believe it is in the early part of 1847, or the latter part of 1846; it is the 9th and 10th of Victoria.

2107. Mr. *Hodges.*] Do you agree with the Report that those gentlemen make upon this. Just read that passage (*handing the Report to the Witness*)?—"When lime is added to such a mixture, the first obvious effect is, that it causes the deposition of a great portion of the suspended organic matter, and a less proportion of that in solution. The offensive hydrosulphurets are decomposed, an insoluble oxysulphuret of calcium being precipitated; the alkaline carbonates and phosphates are also precipitated, the alkalies being left in solution, while the acids are carried down with the lime. Hence the precipitated sewage matter consists of,—organic matter, animal and vegetable; waste matter of stones and roads, produced by attrition; carbonates of lime and magnesia; phosphates of ditto; oxysulphuret of calcium; excess of hydrate of lime. The substances remaining in solution and lost, as far as the manure is concerned, are,—alkalies, potash and soda, or their salts; common salt; ammonia, which is dissolved in the water; small quantities of phosphates; and oxysulphuret of calcium." That is perfectly correct. I can speak to my own knowledge to the effect.

2108. Read on?—"The addition of lime to the sewage water has the effect of depriving it, to a considerable extent, though not wholly, of smell: as it will be pumped from the works into the Thames (according to the scheme of the promoters), it is in a much purified condition, and practically will have no injurious effect in rendering that river impure. The small excess of lime which it contains will rather act beneficially than otherwise, by neutralizing the excess of carbonic acid in the water, and causing a precipitation of chalk, while the small amount of organic and inorganic matter will disappear in the volume of water into which it is poured without producing any injurious result. We are therefore of opinion that the promoters have fully proved the part of their case in which they claim to purify, to a considerable extent, the sewage water before it is introduced into the Thames."

2109. That was one inquiry into Mr. Higgs' patent?—I believe it was; it describes the process very nearly in the same way.

2110. And generally you concur in the opinion of those gentlemen?—It is very clearly expressed; and it could not be more so, I imagine.

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Cross-examined by Mr. *R. Gurney.*

2111. You were examined in a Committee on the Metropolitan Sewage Company, were you not?—I was.

2112. I think your evidence was then to show the great superiority of having manure in a liquid state, instead of a concentrated state?—My evidence related to the presence of ammonia, and those matters that pass off in solution.

2113. Was not that the general tendency of your evidence, to have the manure in the liquid state, instead of getting it in the concentrated state?—Yes, so that the whole constituents should be applied.

2114. The ammonia being lost by the process, which is the object of this company?—It is so.

2115. That is the most valuable part of it?—It is the most valuable part.

2116. You gave evidence as to the immense amount of loss that was incurred every day by the loss of the ammonia?—Yes.

2117. Do you still remain of that opinion?—There is no doubt that that ammonia is lost, and to that extent there is waste.

2118. And therefore you think it is much more advantageous to get it in a liquid state than in a concentrated state by this process?—I imagine that scheme has failed in consequence of the diluted state in which it was applied.

2119. Have you taken any interest in your child since the time you gave evidence?—It is no child of mine; I have only seen the works.

2120. You are only one of its sponsors?—I gave evidence before a Committee of this House.

2121. Have you made any inquiry about it afterwards, to see how far your anticipations have been fulfilled there?—I have heard.

2122. The works are still going on?—Yes.

2123. Have you been to see them?—No.

2124. You have not taken any trouble to ascertain how far your predictions have been fulfilled?—No, I have not.

Cross-examined by Mr. *Henderson.*

2125. I ask whether the process that you examined at Cardiff does not in some degree impair the fertilizing power of the fæcal matter?—Decidedly; if it was applied directly to the land, you would have everything that you do not retain by this process.

2126. A certain sacrifice is made?—A certain sacrifice is made; there is no question about it.

2127. I believe lime disengages ammonia?—Yes.

2128. And that is one of the most profitable products?—And is the most valuable of the ingredients that are contained in manure.

Re-examined by Mr. *Hodges.*

2129. You say that that scheme has failed; I believe by that scheme it was necessary to have the land within the reach of the works?—Yes.

2130. And it has been found that there is not sufficient land, or persons willing to take it, in the neighbourhood, to make it a profitable thing to the company?—Yes. I believe the expense of pumping has been the cause of the failure.

2131. It is not that there has not been found valuable fertilizing matter in this sewage, after it has been so prepared; but the land is not near enough, and the expense of pumping it is too great to make it a profitable investment for the company?—So I have been informed.

2132. No doubt some fertilizing matter of ammonia flows off with this matter; do you see any reason why you should not preserve this portion you speak of, which is capable of being obtained by precipitation?—Certainly not; you would save some, although you would not save the whole.

2133. I think I understood you to say that six-sevenths of that which was held in solution in the liquid was deposited?—No; but the whole that was suspended and in solution, partly in solution and in suspension.

Cross-

Examined by the *Committee*.

2134. Have you considered various schemes for usefully employing the refuse of large cities?—Yes.

2135. At different times?—Yes.

2136. Is the result of your experience that it should be taken in a liquid or reduced to a solid state?—I conceive, in the liquid condition, the expense of pumping is too great as it exists in sewers; there is no doubt about that, in consequence of the diluted state in which it passes through the sewers; the labour and expense of pumping water is so great.

2137. You incline to the opinion that the solid state will be the best to render it profitable?—If every thing could be obtained in the solid state, there could be no doubt about it at all.

2138. Even with the loss that will accrue from having it in the solid state, the loss of the ammonia and the alkalies, you still think the solid state will, on account of the other advantages, be the preferable system?—I think so; if any means could be devised of arresting the ammonia, and converting that into a solid condition, we should have every thing; it would be a perfect scheme.

2139. Now we have been told that the unpleasant odour depends entirely on the insufficiency of lime-water. It is very important to have this milk of lime in sufficient quantities?—I do not think that is quite correct to say it depends wholly on that. If there is not a sufficient excess, there will be a worse smell than if there is no excess. There ought to be an excess of lime, in order to the successful carrying on of the operation.

2140. Have you considered, with respect to this scheme, what quantity of milk of lime would be required to mix daily with the sewage, for instance, of the north of London?—I cannot tell; I may state, that the proportion I estimated to Cardiff was about a pound to 100 gallons, as near as I could estimate; of course that will depend on circumstances.

2141. A pound weight of milk of lime?—The pound weight of lime converted into milk of lime. I do not say this is a very accurate calculation; I made it on the spot, gauging the quantity in the tanks. The tanks, I was informed, were five feet square, and about eight feet deep, and to each tank of that kind, about 7½ pounds of lime were, on the average, added; so that, as nearly as might be, it was about the pound to 100 gallons of liquid.

2142. It would be necessary also that these tanks and reservoirs, into which the sewage is pumped, should be perfectly air-tight?—Certainly they ought to be; there must be openings for entering; it is quite possible to make those air-tight; they ought to be air-tight.

2143. Assuming you are quite correct, which there is no doubt you are, that the liquid manure is more fertilising than solid manure, solid manure has very many advantages over the liquid manure in the facility with which it may be applied?—No question of it.

2144. First of all, it may be transported to all parts of the kingdom?—Yes.

2145. Do you know in sowing turnips that the solid manure is put in with the drill?—Yes.

2146. Are you also aware that they are drilling now white crops, to which liquid manure could scarcely be applied?—Certainly not; it would be used in irrigation, simply to water grass land and garden crops.

2147. Although this sewage may lose some of its properties by being converted into solid manure, is it not rendered much more valuable than if it is mixed with the Thames water, and lost altogether?—No doubt about it.

2148. The motive of the company, in a pecuniary point of view, would be rather to use more lime than to spare the lime, if they could profit by selling it; therefore, as far as the public question is concerned, one has a sort of security that they will get as much out of the water as they can before they return it?—I think there is no doubt of that.

2149. The profit of this will depend partly on the expedition with which the manure is dried?—Doubtless; there is so much to be done, that it must be dried rapidly.

2150. It is also stated in this Report, dated 27th February 1847, which is

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signed by Sir Henry de la Beche, Mr. Wollaston, Mr. Phillips, and Dr. Lyon Playfair: "We are at the same time convinced that parts of the plan are unmatured, and ought to be tested by experience before a large amount of capital is invested in their execution; and in illustration of this opinion, we would cite the proposed method of drying the manure, which, in our opinion, has been devised without an adequate knowledge of the difficulties to be encountered, and which experience alone could remove;" have you considered the plan which is now proposed for drying the manure?—I understand it is to be dried by air, heated by steam, and passed over the surface; I think that would obviate the difficulty.

2151. Did you hear the plan recommended yesterday?—I only heard a part; I did not hear the whole details.

2152. And, as far as you can form an opinion, would that plan, do you think, be applicable for the purpose of drying such a large quantity of manure?—It is rather an engineering question than one on which I can give a decided answer; I do not know the proportion; I have not made any attempt to calculate that.

2153. You cannot give the Committee any opinion on that, not having sufficient experience?—I think not; I think it is a question of experience.

2154. When was your attention first called to that patent?—I really have not seen the patent; I do not know it as a patent; I know it as a process.

2155. Was your attention first called to it by the promoters of this scheme?—No, I heard of it before.

2156. You had not made yourself acquainted with it?—Not specifically; I knew its general features. I am not acquainted now with the details of the specification; I have seen the model, and a certain operation, which is carried out in accordance with the general principles, at Cardiff.

2157. Do you know the mode in which the ammonia may be arrested?—Chemically I know the mode, but I do not know of any mode in which it may be done on a large scale.

2158. Would the fertilizing quality of the manure be deteriorated by means of heating it to a very high temperature in their layers?—It depends on the temperature; if the temperature is below 150 or 160, I do not think any danger would arise.

2159. One hundred and twenty would be, in your opinion, quite safe?—That would be quite safe.

Mr. *John Fowler*, called; Examined by Mr. *Hodges*.

Mr. *J. Fowler.*

2160. YOU are a Civil Engineer?—Yes.

2161. Have you had considerable experience in the construction of public works?—Yes.

2162. Railway and waterworks?—Yes.

2163. Are you engineer to the Bayswater, Paddington, and Holborn Bridge Bill, which has gone through Parliament this Session?—Yes.

2164. And that passes by a tunnel along the City-road?—Along the New-road.

2165. Therefore, among other things, your attention has been directed to modes of tunnelling?—Yes.

2166. You have had considerable experience in matters of that description?—Yes; that is a work of about three miles in length.

2167. Where is that from?—From Bayswater to King's Cross, at an average depth of about 30 feet below the surface.

2168. You gave evidence before the Committee?—No, I did not; I was absent at the moment; and there was no opposition to it, and my evidence was dispensed with; my assistant was there.

2169. Have you examined the plans of the tunnels proposed north and south of the Thames?—Generally.

2170. Have you estimated the power of the discharge of those sewers; we will take the north side first?—Yes.

2171. If that is constructed to the dimensions specified, 8 feet enlarged to 10, at Fleet-street (we will take that first), what is the capacity?—The discharge of that sewer would be 20,000 cubic feet per minute.

2172. You

2172. You observe there are some elbows or bends during the course of that tunnel?—There is one very bad one.

2173. How would you remove that?—That one certainly must be provided for by increasing its area, and also increasing its inclination; that I assume in practice would be done, and on that assumption I have made my calculation.

2174. Therefore you give 20,000 cubic feet per minute; you give that as the capacity of the sewer in the course it is to take?—Yes; I am informed by the engineer of the promoters that provision is made in his estimate for doing that.

2175. Have you also examined the rain-fall of the district round London with reference to the north side of the river?—I have not examined it any further than adopting the figures which I find in the Report by Mr. Hayward, that it was 47 miles square.

The *Chairman* stated that the Committee were of opinion that there was no necessity to go any further into the question of rain-fall.

2176. Mr. *Hodges.*] You say you have examined that Report, and seen the returns made by the city surveyors; will you give the discharge per minute of the ordinary sewage?—I have taken the figures in that Report; I have no doubt they are correct, and I find that on the north side there would be a discharge per minute of 6,250 cubic feet; that is founded on the statement in that Report that there are 9,000,000 cubic feet daily on the north side, and 3,000,000 on the south side; 9,000,000 daily, 6,250 cubic feet per minute.

2177. What on the south side?—In cubic feet per minute, 2,083.

2178. Do you consider that the tunnel on the north side will be sufficient to carry away all the ordinary sewage, with the ordinary fall of rain?—There is no doubt of that, and no doubt it will carry away the ordinary flow of sewage, and a quantity of rain that may be taken at double that of the ordinary flow of sewage, that is, taking them in round numbers; when the ordinary flow of rain does not exceed two-fold the ordinary flow of sewage, then the culvert proposed will be capable of discharging it.

2179. Then the ordinary flow of sewage would leave the tunnel about one-third full?—Yes, just about one-third full; the tunnel is quite incapable of discharging storm-water.

2180. Now, with regard to the south side, do you think the proportions are about the same there?—Not quite; the proportion of the flow of sewage is greater with respect to the capacity of the sewer, than it is on the north side.

2181. What is about the proportion on the south side?—It is as 2,083 is to 5,375.

2182. Now, with regard to the irregularity of the delivery of the sewage, is it your opinion that the irregularity would in any way prevent the tunnel from carrying away the ordinary sewage of the metropolis?—I do not think my opinion is of much value upon that point, because it is simply founded upon that which is known to every one, that the habits of the people of London vary in different parts.

2183. And therefore would be equalized to a certain extent by that circumstance?—From the very large size of London, I should think the equalization would be very considerable, and pretty nearly equal; but I have no better opinion than that which is founded on ordinary observation.

2184. All you know is, that the habits of the inhabitants of the east of London differ considerably from those of the west; it would be greater at one period of the day in some places than in others?—Yes; in a place so large as London, I think that would approach an average; what I mean by average is equal quantities at equal times throughout the day.

2185. The larger the area, the principle of compensation would apply more strongly where the area is large?—The larger the area, the better average you get.

2186. You told us that the tunnels were not constructed to carry away storm-water; would there be any difficulty in leaving the channels towards the river open, so that they may be used whenever the storm-water comes in; there would be no engineering difficulty?—No; when I said it was not capable of taking the

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storm-water, I did not at all mean by that to be understood that I thought it should be made, because I think it is admitted upon all hands that that is a mistake.

2187. Now, I ask you whether you anticipate any engineering difficulty in providing for those passages into the river?—There can be no difficulty in doing that.

2188. And that would be the effect of the storm-water coming in when the tunnels were full, that the other channels would be open?—Yes; I think to do it in the best manner would require a little nicety of arrangement to separate the waters; that is to say, up to a certain point, when the rain-fall was charged with sewage, it should pass into the tunnel until the capacity of the tunnel was exhausted, and then the surplus should pass into the river.

2189. With regard to size, do you consider the size the proper size for the objects contemplated?—In this way I do: if this was proposed as a scheme, to be sufficient for London for many years to come, and to take all the water that will flow down the sewage, and the ordinary rain-fall, I do not think it would be sufficient; but inasmuch as a great part of London can be drained without the expense of pumping, I think to make a tunnel, for the purpose of pumping, larger than this, would be a mistake. In my opinion, the proper way of increasing the main sewer when the time arrives for doing so is, not to make another low-level sewer which requires pumping, but at a level, which will flow by gravitation.

2190. How many years do you think this system would last?—I cannot say.

2191. It would take a long time before London was so increased as to make that upper-level sewer requisite?—That I am not able to answer.

2192. So that you think this would be a step in advance, at all events?—Yes. I think it is a very good step; and I think, however much London may increase, it will not be a work that will be found to be in any way useless or superseded.

Mr. Serjeant *Wrangham.*] I have nothing to ask you.

Cross-examined by Mr. *R. Gurney.*

2193. I understand that you have not made any observations, so as to know whether the sewage does flow equally?—No, I have not.

2194. There are certain hours that the east and west agree in for not contributing to the sewage, are there not?—I should think some time during the night.

2195. Then the quantity that you have given as the flow per minute, in what way have you estimated it; have you supposed it to flow equally for the whole of the four-and-twenty hours?—The 6,250 is equally divided over the whole 24 hours.

2196. How is it as to the other, the 2,083?—That is the same. In the case of the north, being rather less than a third; and in the case of the south, rather more than a third.

2197. I understood you to say that you think the better mode, supposing there should be an excess of quantity, of relieving that, would not be by enlarging this sewer, but by constructing a tunnel at a higher level?—Yes.

2198. Are you aware of Mr. Forster's scheme for that purpose?—Yes, I am, of its general features.

2199. Do you think that was a good scheme?—Yes; as a general measure, I think it was a very good one.

2200. Are you aware that, supposing this Bill were to pass, and the sewage was to be vested in this company, that then there would not be the power of relieving the lower tunnel by constructing one at a higher level?—I am not aware of that; I have not seen any Bill.

2201. Would that, in your opinion, be a great objection to any scheme?—I have not seen any Bill; therefore I do not know.

2202. Would it, in your opinion, be a great objection to any scheme, that any obstacle should be thrown in the way of constructing a sewer upon a higher level by other parties?—When a necessity for that arises?

2203. Yes?—I think so.

2204. It is the natural way of relief to have one which should act by gravitation in that way?—It is impossible to lay down any general rules; it is a question of costs whether it is cheaper to take the old tunnels, and pump it up, or

or make two distinct systems of sewage; that is a matter you cannot lay down a general principal upon; it must be calculated in each individual case.

Examined by the *Committee*.

2205. Your scheme, which was spoken of just now, that has passed through the House of Commons, is a tunnel under the City-road?—It is.

2206. Is your tunnel to be circular?—No; the arch will be a segment, the sides vertical, and an invert when necessary.

2207. Now, what depth under the road are you?—The greatest depth is 30 feet, and the smallest 23.

2208. While that tunnel is in course of construction, will it interfere in any way with the traffic on the road?—It will, to a certain extent; we have, however, clauses in the Bill which restrict the mode of carrying it out; for instance, we are not allowed in any case, within certain limits, to open out more than 500 yards at a time; and in all cases where we tunnel under cross-roads, the cross-roads are always preserved.

2209. Now, you have looked, have you, at this scheme which is now before this Committee?—Yes.

2210. Do you think that while this tunnel is being formed along the main streets of London, it will in any way interfere with the traffic during the time of its construction?—I think it ought not to do. From the size of the tunnel, and the depth under the surface, this work ought to be constructed in a totally different way to the tunnel from Bayswater; this ought to be executed as tunnel, not as open cutting. The rule in the Bayswater work is open cutting and short tunnels under the cross-roads; in this case, it is to be carried out entirely as a tunnel.

2211. While that tunnel is being formed, will it not endanger the traffic over head?—Certainly not.

2212. Not in any way?—Certainly not; it ought not to cause any inconvenience; a work of this kind ought to be carried out in such a way by bringing the material to the surface in such places, as to cause no inconvenience to the public. I do not think it at all necessary as a part of this plan.

2213. As you have looked at this scheme also, could you give the Committee your opinion on the plan adopted for drying the manure?—No, I cannot.

2214. You have not looked at that?—No, I have not.

2215. Considering that you were tunnelling under the city of London, would it not be proper to put in this tunnel with a great deal of care, to take care not to excavate to a greater extent than would be immediately filled up with the tunnel?—Certainly.

2216. Otherwise you might have subsidence which might affect the foundation of the houses?—That might be so; but the difficulty in this case, from the comparatively small size of the sewer, would be much less than that which is ordinarily felt in tunnelling through towns.

2217. Ought precautions to be taken with respect to it; could you trust the men; you have had experience in tunnelling I dare say?—Yes.

2218. Would that involve, the care which you think ought to be taken, would that involve great expense, and ought there not to be careful superintendence of the men while they are excavating?—The work ought to be executed with great care, and ought to be executed, under good superintendence, on a well-matured plan; but I am not aware that any peculiar precaution would be necessary.

2219. Would those precautions be more necessary if you got into gravel?—It would depend very much if the gravel is very wet; I think the worst ground would be the London clay.

2220. It is chiefly London clay?—Yes. I believe that would be more troublesome, perhaps, than gravel; and the way in which it would be troublesome would be the superincumbent weight, and that is neither very great, nor, considering the size of the sewer, difficult to manage. If the sewer was double the size, it would be at least four times more difficult. I should not consider it a difficult work, with ordinary care, under proper superintendence.

2221. You say you do not apprehend any obstructions in the way; have you been in the room during the time the evidence has been given?—No.

2222. You know they propose to take houses in certain places, sink their

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shafts, and then remove all the stuff that is excavated into the road?—It must at some time or other be discharged by the ordinary means of communication, but I think it would be wrong in a work like this to allow the material to be brought to the surface in a public thoroughfare.

2223. As we understand, it is proposed to bring the earth up and discharge it from these houses which they have taken by the side of the road?—Yes.

2224. I ask you whether that would not cause a very serious obstruction to the road?—I think not; I think it may be done in such manner and such times, at night, for instance, as not to be any obstruction.

2225. Have you ever known of any similar work, any tunnel under a great city, constructed in that way?—Tunnels for railways are very common.

2226. They do not generally go under the city?—Oh yes; in Liverpool there are four tunnels under the centre of the town.

2227. What are the depths of the tunnels in Liverpool?—The tunnels in Liverpool vary from 20 feet to nearly 100. There are four which have been executed under the centre of the town.

2228. There is one that goes from the old station quite up to St. George's Hall now?—Yes.

Re-examined by Mr. *Hodges.*

2229. You have been asked about Mr. Frank Forster's plan; is that a plan pointing out the tunnels which he proposes (*handing a map to the Witness*)?—This has got Mr. Forster's name, therefore I suppose it represents his plan.

2230. I believe he proposed a tunnel sewer very similar to this, beginning at the same place, and ending at the same place?—Yes; I look on the work now proposed as the low level culvert of Mr. Forster.

2231. Do you happen to know who was the person who originally proposed a tunnel of this description?—I do not.

2232. You say that it discharges itself at Barking Creek; that is so, is it not?—Yes.

2233. Now what I want to ask you is this: he proposes another sewer at a higher level; does not that also discharge itself at Barking Creek?—Yes; the two were connected with the New River at the River Lea.

2234. So that the whole sewage of London would be brought down to Barking Creek by that plan?—Yes; a very good point of discharge.

2235. Do you think at another day, if necessary, that upper sewer might be added to the present work so made complete, whenever the wants of the population require it?—Yes; looking at the increase of London, some such work as the high level sewer will at some time be carried out. I should say I turned my attention particularly to that before I consented to appear here, to see whether this work would be any impediment to carrying out another sewer for London when it became necessary.

2236. *Committee.*] You have been referred to Mr. Forster's sewer; do you know what the size of that was?—I think it was eight feet.

2237. What year was Mr. Forster's plan?—This is dated 1851.

2238. Mr. *R. Gurney.*] Is it not the fact that the houses in Liverpool have sunk considerably since that tunnel was constructed, and immense sums have been paid as compensation to the owners?—I am not at all aware of that; but the ground in Liverpool is different to the ground here; it is red sandstone.

2239. *Committee.*] You say you are not aware of that; have you any reason to doubt the fact?—I have no reason to doubt the fact or the contrary; but I am quite certain of this, that in the proposed sewer, if such a thing does take place it will be a piece of inexcusable negligence, looking at the character of the ground, and the size of the sewer.

2240. The tunnel at Liverpool was a railway tunnel?—Yes; it would be a very easy matter to carry that out without that damage.

2241. Do engines run up the tunnel at Liverpool now?—Yes.

Mr. *Robert Baxter,* called in; and Examined by Mr. *Hodges.*

Mr. *R. Baxter.*

2242. YOU are the Solicitor promoting this Bill?—Yes.

2243. Are you well acquainted with farming affairs?—Yes. I have been a practical farmer; and for 20 years of my life, about two days in a week were devoted to that occupation.

2244. Twenty-five

2244. Twenty-five years ago, did you and the late Lord Spencer, and other gentlemen, institute an inquiry into the nature of artificial tillages?—Yes; it was under the name of the Doncaster Farmers' Society. The late Earl Spencer, with other gentlemen of the county, in Yorkshire, formed a committee to inquire into the use and advantages of artificial tillage, and we sent inquirers to all parts of the kingdom at that time; and as the first result of our inquiries, we published a work, which I compiled and drew up, on the use of bones as a manure. That was in the very earliest stage of the use of bones, before they had become publicly known; and the report was well received, went through many editions, and I believe led very largely to the use of bones in other parts of the kingdom.

2245. It was very extensively circulated?—Very much so.

2246. For several years?—Yes.

2247. Have you since that period taken a considerable interest in the subject of the application of artificial manures to land?—I have very much so, continuing from year to year a series of analyses of lime, and all matters that would seem likely to be useful in agriculture. I have spent a good deal of time and a good deal of money on the subject.

2248. Among other questions, have you considered the expediency of appropriating the sewage of towns for the purposes of manure?—There never has been any doubt about the expediency of appropriating the sewage of towns for the purpose of manure; the difficulty has been how it could be practically done. There has never been any doubt in the minds of practical farmers that the sewage of towns is one of the richest manures, but from the difficulty in conveying it in a liquid form to any considerable distance, its application has been of a very local nature. I watched with very great interest the progress of the company in London for applying it in a liquid form. I was asked at the time to assist them; but being satisfied that the enormous expense, not merely of pumping the manure, but of laying pipes on every farm to which you must apply the manure, would be so great, that it would run away with all the profits of the company, I declined joining them: I warned them that it was an impracticable scheme—highly beneficial to every sphere to which their pipes were laid down; but as a pecuniary transaction, it would be unprofitable; and I believe that has been the result. I visited their works a few weeks back, and I found they were supplying a very limited quantity of liquid manure; but they were now resorting to a method of furnishing solid manure. The solid manure which they make is formed by peat charcoal, which is laid at the bottom of a tank, and the sewage is then passed through it, and they continue to run sewage through it as long as it differs in appearance at the time of coming out and the time of going in. When the sewage which comes from below the charcoal is as offensive as that which is first put on the charcoal, the process is discontinued; the charcoal is held to be saturated, and is then removed for manure. I bought some, but have not yet had an opportunity of trying it.

2249. *Committee.*] It is 5*l.* a ton?—£. 3 per ton, and they told me they had to pay 2*l.* per ton, or thereabouts, for the charcoal itself.

2250. Mr. *Hodges.*] Did you also become acquainted with Mr. Higgs' plan, the patent?—Yes; several years ago Mr. Higgs' plan was brought under my attention, and thinking it was a method that was practicable I took considerable interest in it. At the time I was asked to join them they had got their Act of Parliament, and I found that the company proposed to be formed under the Act of Parliament was, in point of fact, dissolved; they had no means of going on, and it was impossible at that period to form a new company. Circumstances have occurred since which seem to have prevented the parties from making any effort to form a company with reference to the patent. And it is just one of those things which must gradually make its way into public opinion; as it is tried and tested, confidence will then be gained in it; but that has not been the case, so as to enable the parties to make any great progress with it up to the present time.

2251. Do you consider the principle proposed a sound and practicable one?—Perfectly so; the simplicity of the process commends it as a practical process, and the disposal of the manure is a perfectly settled question. The greatest want of the farmer is an increase of what they call a hand tillage, that is, a tillage that may be sown by the hand, or deposited by the drill. They are now

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paying 10*l.* or 11*l.* a ton for guano, and they find it cheaper in many situations in the country to buy guano at that rate than to buy refuse of towns, carting it the distance they have to cart it to reach their land. The Committee will see that if the farmer can bring two tons of guano with one team, he brings that which will serve for 20 acres, whereas he would have to send his team 20 times for manure for two acres perhaps, and the cost of the carriage is that which prevents manure in any great bulk from being practically spread over the whole kingdom.

2252. Are you therefore of opinion that if solid manure can be obtained from the sewage of towns, that it would be a matter of great national importance?—There is no doubt about it whatever, that if you can produce anything like 100,000 tons of manure from the London sewage, the same thing may be done, in proportion to population, in all other parts of the kingdom; and apart from the sanitary question, it is a most highly important agricultural question, not limited to the neighbourhood of London, but really affecting the whole country.

2253. The market for the sale of such a manure would be almost unlimited?—Quite. The manure will have to find its price according to the experience of the farmer, and whether it be worth 2*l.*, 3*l.*, 4*l.*, or 5*l.* a ton, is a matter entirely to be ascertained from the more extensive use of it. If it is worth the lowest of those sums, 2*l.*, it may be manufactured, and even at less than 2*l.* it can be manufactured at a profit.

2254. Do you consider, therefore, that the price which that manure will reach must be the result of experience, to a certain extent?—It must be so entirely; but inasmuch as towns must have a sewage, and the object of the towns is to get rid of the nuisance, if it is not found profitable for companies to make all the works for converting the sewage water into manure, it will be to the interest of the towns to assist them in the cost of those works; and provided the mere annual working expenses in making the solid manure leave a profit, it will certainly be to the interest of the towns to find all the capital for the remainder of the work.

2255. Now I will go to another part of the subject, with regard to this particular Bill; I believe you have only lately been engaged in promoting this Bill?—No; I had no knowledge of this Bill in any of the preparations for Parliament; it merely came into my hands about a fortnight or three weeks ago; but I found it with the ordinary subscription contract, and a deposit, I think, of 37,500*l.*

2256. The deposit of 37,500*l.* is made?—That is the amount.

2257. And the ordinary subscription contract?—The ordinary subscription contract, to the amount of 750,000*l.*

2258. That is necessary by the Standing Orders, that there should be such a subscription contract?—There is some question whether it would be necessary in a case like this, where the capital is partially to be raised on a guarantee; but at all events, every Standing Order is complied with in this Bill by the subscription contract and deposit.

2259. *Committee.*] We thought for every Private Bill it was necessary to have two-thirds?—Not if it is raised on the credit of rates, you need not have a subscription contract.

2260. Mr. *Hodges.*] Do you consider that the subscription contract, in ordinary cases, practically affords any great confidence to the scheme?—If you mean whether it ensures the carrying into effect the work, certainly it does not: it is not of the slightest use. Legally, I believe the company has a right to register the parties who are parties to that subscription contract; but then the parties registered have the right to transfer their stock immediately, and they may transfer it into names that are not responsible, so that that affords no security. If you desire to have a security for the completion of the scheme, there is no other means of doing it than by requiring a certain sum to be paid up within a limited time, and letting that sum be impounded for the execution of the scheme.

2261. To get rid of all difficulty with respect to the subscription contract, would there be any objection to the insertion of such a clause in this Bill?—I believe none whatever; in cases of railways the amount impounded now is 10 per cent. on three-fourths of the estimate.

2262. Do

2262. Do you believe an adequate Board of Directors are prepared to come forward and undertake this scheme, and make that deposit?—Yes.

2263. If the Committee should be inclined to sanction the Bill?—I believe so.

2264. Have you reason to believe that the exact state of this company was laid before my Lord Palmerston when his attention was called to the provisions of this Bill?—When the matter was put into my hands, I inquired why greater progress had not been made in the ordinary machinery of a company, such as holding board meetings, and the issue of shares, and deposits paid up on the shares, and so forth. The answer given to me was, that until the question was determined whether the guarantee were or were not given, the promoters deemed it inexpedient to ask their friends to form a Board of Direction; but on ascertaining that such a principle would be sanctioned, they would immediately proceed with that machinery. I then naturally asked, When you asked for sanction at the Home Office of that principle, did you explain the circumstances in which you stood? and they assured me that that explanation was explicitly given. I merely mention this as a cautionary inquiry which, as a professional man, I felt due from me to make. When I found that the company had not gone forward on these details of having board meetings, issuing shares, and taking the deposit, I inquired why it had not been done, and received the explanation, which to my mind was satisfactory, when I was inquiring whether I should be concerned in the promotion of the Bill.

Cross-examined by Mr. *R. Gurney.*

2265. You say this sum has been subscribed for, and deposits made; I believe there are five subscribers to this subscription contract?—I believe so.

2266. Two of these are gentlemen of our profession; Mr. Massey Dawson subscribes for 100,000 *l.*?—It is so.

2267. Mr. Cotterill, another barrister, subscribes for another 100,000 *l.*?—Yes.

2268. A gentleman recently called to the bar?—I do not know him.

2269. Do you know Mr. Dawson?—No.

2270. Mr. Morewood subscribes for 350,000 *l.*?—Yes.

2271. Mr. Mitchell is down for 100,000 *l.*?—I think not.

2272. Five thousand shares of 20 *l.* each?—Mr. Mitchell informed me that he is not one of the parties to the contract; that is not the engineer.

2273. Mr. Alfred Mitchell?—Mr. Mitchell, the engineer of this company, told me he was not a party to this contract.

2274. Do you mean that these deposits have been paid by these five gentlemen?—Certainly.

2275. That Mr. Dawson has paid 5,000 *l.*?—No; how it was made up I cannot tell you; the parties have paid in their deposits, or otherwise the Bill would not be where it is.

2276. With your experience on Railway Bills, you are aware very often a sum is deposited where the subscribers are not the persons who have paid the money?—I should think, in five subscription contracts out of six, the parties who sign the contracts do not individually pay any sum whatever, but having signed their names for the sum of money, it is put down by their friends, or some of themselves; but there is not an individual contribution to the amount of the subscription, in one subscription contract out of five, in my experience.

2277. I was not aware it was so bad as that?—Whether it was meant to be allowed I cannot tell; it is practically treated as a form now, parties subscribing, and parties depositing; now, in five cases out of six, parties do not deposit who are the parties subscribing; that fact has been brought before the Standing Orders Committee, and they say it is no objection whatever.

2278. In consequence of that practice, the Committees are directed to inquire into the solvency of the parties subscribing?—No; it is competent to the Committee to inquire, of course, into that, as into everything else.

2279. There is a Standing Order obliging that?—(*No answer.*)

2280. You have no doubt that an adequate Board of Directors will come forward if the guarantee is sanctioned?—I have every reason to believe so.

2281. At present are there any directors who have come forward?—Yes.

2282. But these five gentlemen?—Yes.

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2283. Are there some directors who have not subscribed?—Yes.

2284. Who are the directors now?—The directors are not fully formed; I have names of parties who desire to be on the direction; I have the names of other parties who desire a little time to be admitted, if it is thought proper.

2285. Then there are no persons at present appointed as directors?—The direction is not at present filled up.

Re-examined by Mr. *Calvert.*

2286. Is there any doubt, supposing the three per cent. guarantee is carried out, in pursuance of the favourable opinion expressed by the Home Office, that capital in abundance will be forthcoming for this undertaking?—There is no doubt that if the Bill be passed with a guarantee of 30,000 *l.* a year, and the prospects attached to it, that a body of directors will be formed, and a company formed, and capital subscribed to carry it into effect.

2287. *Committee.*] Now with respect to the guarantee fund, do you consider that essential?—Perfectly essential; the advance in the preparation of town sewage manure is not so great as to create a perfect confidence in capitalists without such a guarantee; the expense of these works you will see is about a million of money, to convey the sewage down to the point at which it is to be operated on. The capital for operating may be about 100,000 *l.*; there will be no difficulty in finding the capital to operate on the sewage; but a great difficulty in finding a million of money to carry it to be operated on. The public must convey sewage down there; but with that risk, the thing is perfectly apparent.

2288. Mr. *Calvert.*] If the Commissioners of Sewers were to make the sewers, the public must pay for it?—Just so; if the Commissioners of Sewers choose to make sewers down to the point where the sewage water would be operated on, there would be no difficulty in forming a company with a capital of 100,000 *l.* to operate on the sewage water.

2289. Is that your principle, that so far as this is an undertaking for the public good, there shall be a guarantee, but beyond that, it should be a matter of private speculation?—It seems to me that that part of it which specially relates to taking the sewage out of the body of the town, where it creates a nuisance, should be at the public cost, or at all events, the public should run the risk of it. If there should be profit coming out of it, the public will have the first benefit of that profit: the conditions imposed, as I understand them, being, that whatever profit is made from the manure shall go in mitigation of the public guarantee; and if the profit just reaches the three per cent. the public will be relieved without the company obtaining any further benefit than the three per cent.; and it is only when they get beyond the three per cent. that they will then divide profits beyond the guarantee.

2290. So that if it is done by public Commissioners it will be at the public cost, first and last, without any repayment; whereas if it is done by the company it will be done by such a sum guaranteed by the public, but ultimately, perhaps, without cost at all to the public?—That is precisely the case.

2291. *Committee.*] In case it were done by the Commissioners of Sewers, and the Commissioners let the sewage at the extremity of it for a sum between three and six per cent., in that case that sum would go to the credit of the parties, the Commissioners of Sewers, and in this case it would go into the pockets of the company?—Yes; if you could have the same confidence that the Commissioners executing the works for themselves, would be as much alive to making a profit out of it as executing a public work, and would have the same regard to obtain an ultimate profit from it, the case would be equal; but I conceive that a private company would be far more likely to get a profit out of this transaction than any public commissioners. The difficulty with a public Board is always to get a scheme into operation. The element of the Board, or the energy of the Board, is that rather of obstruction than forwarding a work. The difficulty is, to find a work which in all its details shall meet with the approval and energetic countenance of the majority of the Board; and if you come to matters of profit, it is notoriously incapable. No man feels an interest at a public Board in taking any trouble to further a profit which does not affect himself individually. In a private company it is the direct interest all the way through,

through, and that very principle of interest, no doubt, wherever it can be applied to public works, is an efficient mode of carrying them into execution.

2292. Mr. *Calvert.*] The best prospect of obtaining a remuneration to relieve the ratepayers, is to put it in the hands of a private company, rather than a public Board; is that so?—I think so; and from my communication with the parties connected with the Commissioners of Sewers, if the plan is not remitted in this Session, or some early Session, to a private company, I do not believe there will be any other plan whatever for years to come.

2293. Are you aware whether the Commissioners in 1851 did not make a report, to the effect that they would be able to raise the money for this purpose at 4 ½ per cent.?—They made an arrangement for 4 ½, but in consequence of an alleged want of powers in their Act of Parliament, the parties ultimately refused to trust them, thinking their powers were not sufficiently beyond doubt to enable them to borrow money, so they could not get the money at all.

2294. You were asked about these directors; are they persons of considerable property in themselves, and really solvent and rich people?—Yes; I am accustomed, of course, to look at those matters.

2295. *Committee.*] Have you paid attention to the clauses and structure of this Bill?—No; I have been rather directing my attention to the other points of the case; the Bill was printed before it came to my hands, and knowing that the clauses must be very much modified, I have not really paid attention to them. When I learn the opinion of the Committee, I am sure those clauses may be modified, and I am therefore waiting that period.

2296. Have you looked to the Bill sufficiently to say whether the objection first raised is not correct, that if this Bill were to pass in the state in which it is, no other person could construct a high-level tunnel; it must be done either by this company, or with their concurrence, they making such terms as they think proper?—I think, unless there be a distinct provision for that purpose, that this company might say there is an interference with the sewage.

2297. The 26th clause seems to vest in you absolutely the right of all sewage from all the existing sewers?—Yes. I would suggest on that head, that there should be a power given, either to the First Commissioner of Public Works or some other party, to order any sewer which he may consider necessary for the sanitary state of the metropolis, and that the company in that case should not have the power of objecting.

2298. So again with respect to the size of the tunnel itself, and the branch communications with the existing sewers, those do not seem to be at all fixed by the present Bill?—Those are not defined by the present Bill; and the Standing Orders which apply to railways, and keep a railway within the bounds of their deposit, do not apply to this clause of the Bill.

2299. Would not this Bill, as at present framed, allow the company to alter even the size of the main tunnel, and diminish it so as to confine it entirely to a capacity sufficient for the carriage of mere sewage matter?—No.

2300. What restrains you?—I think, their having shown on their plans and sections certain dimensions.

Mr. *Calvert* begged to draw the attention of the Committee to the 23d clause of the Bill.

The *Witness.* There is no objection to define the dimensions in the Bill; and it would be much better to do so.

2301. *Committee.*] So with regard to the branch communications, there is a power given you to alter those from time to time; such power would be highly improper to leave in the Bill?—Unless subjected to the revision of some competent authority acting on behalf of the public.

2302. Because otherwise you might take just as much as served your purpose, casting into the river that which would pollute the river, but which would not be worth your while to pump up?—Yes; besides, in works of this kind, the Standing Orders do not limit you as to size; and it would be better, and perfectly easy for the Committee to express any opinion they please about the size of the tunnel. It is eight feet to ten on one side, and five feet to six on the other. Those can be enlarged within certain limits without any considerable in-

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crease of expense; and the Committee can exercise their discretion upon that without interfering with the Standing Orders, or capital of the company.

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2303. You admit the propriety of expunging from the Bill any provision which enables you to alter the size of the branches?—Without supervision, because it might only take in the smaller quantity of matter which is rich in sewage, without taking in the larger quantity, which is a nuisance to the neighbourhood.

2304. Who do you propose are to pay the guaranteed sum?—The Commissioners of Sewers.

2305. Can you say how practically that would operate; does that enable you to say whether it would be cast by an uniform rate over the whole jurisdiction, or whether it would fall in a higher degree on those who are nearer the river, and in a less degree on those who are more remote from it?—As regards this company, they would ask the certificate of the First Commissioner of Woods and Forests; and on his giving the certificate, with an order on the Commissioners of Sewers for the sum to be paid to this company, that would end the transaction as between the company and the Commissioners of Sewers. I have been conversant with the proceedings of Commissioners of Sewers for many years, and I know Commissioners of Sewers have power either to lay their rate by a poundage, or to lay it according to benefit; but I have found, practically, that the question of laying it according to benefit is an exceedingly difficult one, and is so difficult, that in Yorkshire and the low country there is so much difficulty in laying the rate according to benefit, as for the last 50 years, in spite of the remonstrance and disaffection of the whole district, to have practically prevented any other course being taken than that of an acreage rate.

2306. It is admitted by the evidence that has been called by the company that a large portion of London which they have specified, for instance, Piccadilly, Oxford-street, and all the higher portion of the north side of London, would get no special benefit from this, other than such benefit as may result from such purification of the Thames as would be occasioned?—That is the whole result.

2307. Whereas, on the other hand, it is stated that another large district, whose sewers are all considerably below high-water mark, would be very largely indeed benefited, so far as the mere sewage of their district is concerned?—I quite agree there will be an inequality of benefit; the whole of London will be benefited by the improved sanitary state of the atmosphere; for any one can see that the 600 acres of putrid mud on the banks of the Thames, exposed to every change of the tide, does create a body of malaria that will affect to a certain degree the whole of the town; besides that, it is known that diseases which are generated in the low districts may travel into the high, so that Belgravia may be invaded from the slums of Westminster very seriously.

2308. Have you contemplated that this sum is to be paid by an uniformly imposed rate, to use the argument which you have been adducing as a reason for such a rate?—I am not intimately acquainted with the subdivisions of London in their rates; it is possible that the lower parts of London, where the sewers have to be formed at a much greater expense, and supervised also much more frequently, may have established a disparity of rate. In the district of Yorkshire to which I have alluded——

2309. Do not go to Yorkshire?—There was a disparity of rate, but still within the district it was an acreage rate; and within such a district it must be a poundage rate.

2310. Do you know practically in London any low level ground to which you have referred where there is a different rate now levied by the Commissioners?—I do not.

2311. Do you think it would be right under this Bill it should be?—Yes, if it is practicable.

2312. Are not those districts amongst the poorest districts of the metropolis?—They are, certainly; but the landlord, in his rent, will settle the question of rate, and not the occupant of the house.

2313. Do you not think it will have to come on the occupant, more or less?—No. the rent will be fixed by computation with houses in other situations; it is not of necessity that men should live in that low district.

2314. Except

2314. Except that the houses are cheaper there; from its being partly a less populous district, people do not like it so much, because it is not so healthy?—If the houses are cheaper there, that computation does not apply; if there are other districts equally cheap, then the proposition will be a true one; but in all parts of London, if a labourer can get a house for 6*d.* a week less, he is sure to migrate to that part of London and take it; he does not care whether it is healthy or unhealthy. I am sorry to say, that from my acquaintance with the poor of London I am led to believe that they are exceedingly careless about their health.

2315. Then your tax will be laid in the highest degree on the poorest districts?—I think it would be paid by the owners of property, rather than the occupants.

2316. Your counsel stated that the amount of this tax, according to his calculation, would be about three farthings in the pound; are you able to say on what calculation that statement was made?—No, I am not; I am told from so many quarters that it is so, that I believe it will be correct, that the total amount at which the sewers rates of the City and the metropolis generally arrive, will yield, at three farthings in the pound, 30,000*l.*

2317. According to this Bill, and it appears from the answers you have given, according to your intention, and in which the Bill would not be altered, assume that this were to turn out altogether a failure in a commercial point of view, still the liability to pay three per cent. upon the money expended would be a perpetual liability, whatever becomes of the undertaking, if the million is expended?—No doubt; but I presume the promoters will be put under terms by a clause that the 30,000*l.* will not be paid unless the works are completed within a certain period.

2318. I assume the expenditure to be made, and then it turns out to be a failure; then I imagine that it is your intention that still there should be a perpetual payment of three per cent. to those who furnish the money?—No doubt that payment is in respect of works which will have been completed before the 30,000*l.* is paid; and if the commercial speculation fails entirely, still London will have the benefit of this sewage, which will be perfectly efficient.

Mr. *Calvert* stated that the Government had the power to purchase at a valuation; and if it turned out to be a failure, to get it for less.

2319. *Committee.*] Now, there is a portion of the tunnel (*referring to the Map*); four miles is the extent of it; between those two creeks?—Three miles.

2320. No sewer will be let into the tunnel there?—None whatever.

2321. Therefore for that purpose it is valueless, that extension of it, and you get at the more distant creek seven feet below the surface, thereby increasing the continual expense of pumping, and also increasing the expenditure necessary for constructing that; it was suggested that that was done in compliance with the Commissioners' wishes; are you able to state the circumstances?—Yes; the Commissioners in Mr. Frank Forster's plan had gone down to the same point, and the promoters of this Bill thought it would be more satisfactory to the Committee that they should take it as far down the Thames as had been projected by the Commissioners of Sewers; but I quite agree that this may be most advantageously stopped at Bow Creek, and that the other need not be made. I have asked for an estimate of the difference of cost, and I see it will be 111,000*l.*

2322. Besides the expense of pumping at the deeper level?—Yes.

2323. Now, assuming your experiment to succeed, and the water, as you say, to be more clarified, there could be no objection to its being passed into the Thames at a nearer point?—Not the least; and equally on the south side.

2324. Assume that it was abandoned, and that you lift the water up from the tunnel without its being purified, into the Thames, there would be no difficulty then in superadding that part of the work if it was thought desirable?—Not at all; it is merely the construction of the retaining reservoirs at Bow Creek, to be opened at the first three hours and a half of the retiring tide, so as to carry sewage water beyond return.

2325. As far as the views of the company go, they not only see no objection, but seem rather to concur in the view that I am now taking, but took the other course in deference to the views of the Commissioners?—Quite so; and on the south side the same thing occurs at Deptford Creek; it is taken down below Woolwich; it might in the same view be stopped at Deptford Creek, where the lift is into a higher tunnel, and with the same results; that would be a saving of 44,000*l.*

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2326. So that you would save 150,000 *l.*?—Yes, and the addition; adding a little to the tunnel, one foot of diameter to the north tunnel would be 41,000 *l.*, adding a foot to the south tunnel would be 9,000 *l.*, or two feet to the south tunnel would be 22,000 *l.*; so that within the limits of the capital there is ample marg in for varying the dimensions of the work, if the Committee think it desirable.

2327. Did it ever enter into the contemplation of the company to try the experiment on a less scale; now, for instance, to start with the Fleet Ditch, and go through that portion of London which it is admitted will be improved, owing to the lower level of it, and so render the undertaking a less costly one in the first instance?—It is a pity one of those was not carried into effect. One was begun at Puddle Dock, but by the mismanagement of the gentleman who had charge of it, after he had got three quarters of the way through with the whole thing, he quarrelled with it and threw it up, and it was not carried into effect. But the experiment on a small scale, as regards the operation itself, of course is less satisfactory in its results than an experiment on a large scale. If it be operated on on a large scale, it must be more generally satisfactory; there is more science brought to bear, there is more care taken in the process, and the results will be better. Of course the labour is not to be compared; the labour required for one set of works at a termini compared with the labour required at separate sets of works, as was suggested by the counsel, which would be 50 sets of works on the side of the Thames; the Committee can estimate so many pumping engines, 50 pumping engines, and 50 different establishments, would increase the per centage of the manufacture very greatly.

2328. Mr. *Henderson.*] Are you aware that the power of rating of the Commissioners of Sewers is limited in amount under the present Act?—It cannot be limited lower than 1 *d.* in the pound.

2329. Are you aware that the funds which the Commissioners have under their control are insufficient for their present necessary works?—I am not aware of that; but if it be so, if they cannot maintain their sewage, it is time that their powers were enlarged, because sewage is a matter on which you cannot halt; you cannot live over a cesspool.

2330. *Committee.*] Are you aware, in your Parliamentary experience, of any one single undertaking where Parliament has given a sanction to a guarantee?—I am not apt at remembrance; I do not remember one at the present time; a case, which rather surprised me, was called to my attention the other day, where a private company had received powers for make sewers for a town, with powers to raise the rates. I did not know such a thing existed; but Mr. Mylne, the engineer of the New River Company, said such a thing was.

Mr. *John Joseph Morewood* called; Examined by Mr. *Calvert.*

Mr. *J. J. Morewood.*

2331. I BELIEVE you are the originator of the scheme of this drainage?—Certainly.

2332. And the principle contained in the present Bill, of carrying the sewage away to the verge of the population, is one which you yourself have continually sanctioned?—Yes.

2333. Have you been engaged in the consideration of this subject for several years past?—Constantly, for the last eight years.

2334. *Committee.*] Are you an engineer?—No, I am not; I am the promoter of this plan, which I have devoted myself wholly to for the last eight years.

2335. Being an engineer did not lead you to it?—No.

2336. Were you in any way scientifically connected with the subject?—No; I took a great interest in the state of the Thames in 1826 and 1827.

2337. Are you of any profession?—No; in the year 1832, when the cholera came, I found that the poor people were suffering excessively from the retention of sewage, and so my attention was directed to the subject; and this project occured to me when I was one day walking through Leadenhall Market in 1845, and from that time I have wholly devoted myself to it.

2338. And you have spent a considerable sum of money in experiments upon this subject?—Yes.

2339. Eleven thousand or twelve thousand pounds?—Yes; together with that which I consider in honour due to others, the amount is very much larger.

2340. Going back to the autumn of 1845, were Parliamentary deposits then made with a view to a Bill?—Yes.

2341. I believe in the Session that followed the Government appointed a Committee to investigate the sewage schemes?—Yes.

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2342. Of those schemes one was a liquid manure?—Yes.

2343. The company for a liquid manure had a Bill then before Parliament?—Yes.

2344. The other was dry manure; you had no Bill for dry manure at that time?—Sir Robert Peel's Government were desirous that we should proceed, but there was a difference between the promoters; and then Sir Robert Peel's Government said, We can do nothing further, but we will appoint a Select Committee to inquire into the whole subject.

2345. Was a report made by that Committee?—Yes.

2346. Have you that report in your hand?—Yes.

2347. Was that report in favour of the dry system, or the liquid system?—They sanctioned the liquid. Sir Robert Peel's Government went out just before that report was issued, therefore we did not further prosecute the thing. The Honourable Bingham Baring was chairman. As the Government went out, and we lost that support, we did not press the thing upon them, but were compelled to let the thing take its course.

2348. In the autumn of 1846, did you again make Parliamentary deposits?—Yes; those consisted, amongst others, of notices on 85 parish doors, which had to be on every Saturday for three succeeding weeks in November, so as to have evidence of their being on the parish church doors for three succeeding weeks in November; and I superintended that throughout, so that there might be no flaw in our proceedings.

2349. At that time, the Government intimated to the Lord Mayor that they intended to bring in a Bill for that purpose?—Yes, and therefore they did not proceed.

2350. That was in respect of the Session of 1847?—Yes.

2351. In the autumn of 1847, with a view to the Session of 1848, were Parliamentary deposits made a third time?—Yes.

2352. Was the Bill presented to the House?—Yes.

2353. Did it stand for second reading on the 7th March?—Yes.

2354. It was then stopped by a resolution of the Commissioners of Sewers?—Yes.

2355. Just put in those resolutions?—Yes.

2356. *Committee.*] What year was this?—1848.

2357. Mr. *Calvert.*] In the end of 1847, the Government of the day cancelled the separate commission that had been issued, and issued a commission comprising the whole metropolitan district, saving the city?—In accordance with the recommendation of the Sanitary Commission.

2358. I believe an entirely new Board was appointed, comprising the most eminent engineers of the day?—In 1847 they were merely gentlemen connected with the Sanitary Association; in 1849 the eminent engineers were appointed.

2359. In 1851, did you, for the fourth time, complete your Parliamentary plans and deposits?—Yes.

2360. Did you issue notices then as before?—Yes.

2361. At that time, I believe the report was published by Mr. Frank Forster?—Yes.

2362. Did not the report sanction the principle which had been suggested by you?—Yes.

2363. In the Session of 1852, you were proceeding with your Bill?—Yes.

2364. A change of Government prevented your receiving much attention at the Home Office at that time?—Yes.

2365. And therefore you suspended it till a more favourable opportunity?—Yes.

2366. Last autumn again, for the 5th time, you made your Parliamentary deposits?—Yes.

2367. Did you bring your plans under the consideration of the Office of Woods and the Home Office?—Yes.

2368. Was that favourably entertained by those offices?—My Lord Derby, as well as Mr. Disraeli, Lord John Manners, and Mr. Walpole, were seen on the subject.

2369. Did they express themselves favourably?—Yes.

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2370. Did they give any definite answer before they left office?—Lord John Manners appointed an interview on the 4th of December for the 7th of December, and then there was a deputation representing very leading capitalists who were to come forward and form the company. When they saw him, he said he would bring before his colleagues the question with respect to the guarantee; and before we received an answer they went out of office.

2371. On the change of Government, on Lord Palmerston succeeding to the Home Office, was the matter brought under his consideration?—Under the consideration of Sir William Molesworth and Lord Palmerston.

2372. Do you recollect about what time the matter was brought under their consideration?—The day they were appointed, or the day after; Lord Palmerston had made a speech at Lewes so decidedly in favour of using the dirt of towns for the country, and the Earl of Lonsdale had taken that up in Westmoreland, urging that the solid was the only practicable plan. It was therefore prominently before them; and in the position we were, we could not lose a day.

2373. That speech was made at an agricultural meeting at Lewes?—Yes.

2374. *Committee.*] Did you attend that meeting at the Home Office?—No; Sir Charles Fox did.

2375. Mr. *Calvert.*] Supposing the present plan is carried out, will it remove the nuisance, and the miasma from the Thames?—Yes; that is generally admitted.

2376. Have you considered the question of the manufacture of manure much?—Yes.

2377. Is that question advanced in the public opinion so as to induce capitalists to trust in it without some guarantee?—No, it has not.

2378. Have you had offers of means to carry out the work, provided there was a guarantee of three per cent. for carrying out the work?—Provided it can be shown that the work can be accomplished for a certain definite sum.

2379. Will the evidence obtained here from Mr. Oglevie and Mr. Brassey satisfy that part of the condition?—Quite so.

2380. Therefore have you any doubt that with the three per cent. guarantee, and the undertaking given by Mr. Oglevie, that you can obtain the capital for the purpose of carrying out the scheme?—No doubt.

2381. Have you been anxious always to procure the concurrence and good-will of the Commissioners of Sewers with reference to this plan?—Certainly; I have endeavoured continually to act together with them in the matter.

2382. Are you acquainted with all the plans of Mr. Wickstead at Leicester?—No.

2383. Have you any description of Mr. Wickstead's works?—I have the book which he sent me.

2384. Is that for liquid or dry manure?—For dry manure.

2385. Perhaps you will put in any description you have; is Mr. Wickstead's plan identical with that of Mr. Higgs?—Yes; it is the same.

Cross-examined by Mr. *Clark.*

2386. You mentioned that your scheme had been attempted to be brought forward for several previous years?—Yes.

2387. I suppose Bills were on some of those occasions prepared?—Yes.

2388. You have laid them on the table?—Yes.

2389. Did those Bills contain any clause with a guarantee?—Not the first.

2390. Has any Bill before the one of this Session?—Yes.

2391. What one was that?—Last year.

2392. The Bill of 1852?—Yes.

2393. You state that if that guarantee were now obtained from Parliament capitalists would be ready to form the company?—Yes.

2394. Do you give the Committee to understand that no company is formed at the present time?—Mr. Baxster has already stated the position with regard to that.

2395. I think not; we have heard with respect to the subscription contract; has there been a subscription agreement; has any company been formed; is there an existing company at the present time?—It is registered.

2396. What

2396. What number of shares have been allotted, if any?—Mr. Baxster has already explained the position to the Committee with respect to that.

2397. You are the registered promoter?—Yes.

2398. So that it is a fact within your knowledge what the state of the company is at the present time?—It is impossible to put it in a better position; so long as the Commissioners of Sewers stand always opposing, it is impossible for any combination to be formed to carry it out by commercial enterprise, which the Committee of 1846 stated was the only means of carrying it out.

2399. Does the subscription contract with these five names represent the company as it exists at the present moment?—Yes.

2400. You claim to be the originator of this scheme?—I worked at it four months before I engaged Mr. Wickstead.

2401. You had not heard, yourself, of the idea of tunnel sewers until the year 1845?—It never occurred to me till 1845; we fixed on the site during the first week in October.

2402. Mr. Wickstead has worked a good deal at this sort of scheme since that time, has he not?—I think so.

2403. He has considered a good deal the mode of relieving towns of their sewage?—Yes.

2404. He is at present engaged in endeavouring to relieve the town of Leicester of its sewage?—Yes. I have written to him, and requested him to come up and give evidence on the subject. He is not sure whether this thing will be left in the hands of the Commissioners of Sewers, or in the hands of a private company; he wishes to see how that is decided before he takes any step.

2405. Mr. Wickstead, instead of being guaranteed by the town of Leicester, guarantees himself the corporation?—I have understood it is only the outfall works which he made, amounting to 16,000*l.*, and not the construction of the sewers at all; we propose to combine the two.

2406. Do you mean that Mr. Wickstead only constructs the outfall works, and that the corporation of Leicester constructs the tunnel?—So I understand.

2407. You are quite aware that Mr. Wickstead has no guarantee from the town of Leicester; and, to some extent, he guarantees them from loss?—When there is a profit; that we divide.

2408. Answer the question?—I am not at all aware; I have not been able to go down at all.

2409. You have alluded to the report presented by Mr. Frank Forster, who was the engineer of the Commissioners of Sewers in 1849, in which Mr. Forster sanctions your idea?—In 1850.

2410. Was not one main part of Mr. Foster's scheme to make a tunnel at a high level, so as to drain a large portion of the town by gravitation?—Yes.

2411. That is no part whatever of your scheme?—No. What I claim is the low-level drainage, that in fact which provides for the drainage, in so far as there ever was any difficulty in the drainage of the metropolis. It is a natural thing for sewage to flow towards the river from a high level, and this high-level sewer may be wanted "at a future day," as stated in the report of the surveyors to the two Sewer Commissioners.

2412. The intercepting tunnel at a higher level?—That I do not claim at all.

2413. The difference being at your low level, you pump at the extremity?—In that pamphlet Mr. Wickstead states what we claim. Mr. Wickstead gives a short account of the whole in his own words. He says: "In the autumn of 1847, Mr. Morewood, one of the active projectors of the original company, thinking that the object proposed was of such public importance that the Legislature would be induced to dispense with the Standing Orders as regards the amount of subscription, endeavoured to obtain an Act, with the sanction of Government, considering that there would be no difficulty in obtaining the necessary amount of capital for carrying out the project. In the following account of what was done by him, I beg leave to use his own observations: During the autumn of 1847, all the Standing Orders were again complied with (I presume with the exception of those relating to the amount of subscription), and a Bill was duly introduced to incorporate a company by the name of the Great London Drainage Company. Mr. Morewood stated, that though all the Standing Orders had been complied with, that there was no petition against,

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and the Commissioners of Woods and Forests were favourable to the Bill; yet the Metropolitan Commissioners of Sewers passed certain resolutions (7th March 1848) against all further progress of the Bill, declaring that in the opinion of this Commission, no plan for appropriating the contents of the metropolitan sewers ought to be entertained until the general survey and levels should be completed. Several endeavours were subsequently made to obtain the sanction of Government for proceeding with the Bill, seeing that the general survey had not the remotest connexion with a tunnel sewer intended to pass under the lowest watercourses, and seeing that the Government did not bring forward their scheme for draining the metropolis. All further progress with the Bill was unconditionally and peremptorily refused by the Government. From the foregoing statements, it appears evident the promoters of the enterprise have a right to claim to be the first who proposed, 1st. a tunnel sewer, effecting an uninterrupted flow of the contents of the sewers by means of an artificial outfall; 2d. The collection of the refuse to be applied to agricultural purposes, either in a liquid, a moist, or perfectly dry state; 3d. The deodorizing the sewage by means of lime, which does not deteriorate nor lessen the value of the solid manure; 4th. The establishment of facts which prove the thorough practicability of the plan, and giving the fullest assurance that the necessary works may be constructed in consideration of the refuse, now worse than wasted; 5th. And that the works when constructed will be no nuisance to those residing in their neighbourhood; and, lastly, I think the promoters have unceasingly endeavoured to effect the national objects in contemplation, without any charge to the ratepayers, through the agency of commercial enterprise; and there can be little doubt of their eventual success, if the sanction of Parliament were given, in accordance with the Report of the Select Committee in 1846, herein referred to."

Cross-examined by Mr. *Henderson.*

2414. You said that Mr. Wickstead's plan at Leicester is identical with this?—Yes.

2415. Are you aware that the works which Mr. Wickstead has undertaken are still incomplete?—Yes.

2416. He has not yet been able to make any experiment as to the work, or the manure so produced?—I have heard that there has been a quantity made; to the amount of 50 tons has been made, but they want to keep it quiet.

2417. The works are not yet complete?—No, those works are new.

Re-examined by Mr. *Calvert.*

2418. When Mr. Forster sanctioned the principle of the scheme, did he sanction the low-level tunnel?—Yes.

2419. Then you would only have to add the high-level tunnel?—Yes.

2420. And you say a high-level tunnel might be made by anybody?—Yes.

2421. And that would take off a portion of the sewage, and the storm-water and the rain-water?—Yes.

2422. There would remain only the more difficult part of the sewage to be done by your low-level drain?—Yes.

Mr. *Calvert* stated, that before offering any further evidence, the promoters would like to have an opportunity of considering the effect of what had been given. If they thought it necessary to go into any further evidence, it would only be of an engineering nature.

The *Chairman* inquired what course the Commissioners proposed to take in the event of the promoters closing their evidence.

Mr. *Henderson* replied that the Commissioners would like to have an opportunity of considering what course they would take.

Mr. *Clarke*, on the part of the City Commissioners, stated that it would be part of their duty to give evidence against the preamble on the engineering details, and as to the insufficiency of the scheme to carry out the objects contemplated by the Act.

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The *Chairman* inquired whether, if the Metropolitan Commissioners were not ready to go on with their evidence to-morrow, the City Commissioners would be prepared to go on.

Mr. *Henderson* replied that either one or the other would be prepared to proceed.

[Adjourned till To-morrow, at Twelve o'clock.

Veneris, 10° *die Junii*, 1853.

LORD SEYMOUR IN THE CHAIR.

Mr. *Calvert* handed in a return, showing the amount that would be produced by a rate of three farthings in the pound. With regard to the precedents in aid of the proposed taxation, he wished to lay before the Committee the Killarney Junction Act, the Leicester Waterworks Act, the Westminster Improvement Act, and the Act of Cork and Bandon Railway; he also stated that he should not call any further witnesses.

Mr. Serjeant *Wrangham* then proceeded to open the case on behalf of the Metropolitan Commissioners of Sewers.

Mr. *Joseph William Bazalgette*, called in; and Examined by Mr. *Henderson*.

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2423. ARE you a Civil Engineer?—I am.

2424. Are you the engineer of the Metropolitan Commissioners of Sewers?—I have been for four years with the Commissioners.

2425. During that time have you directed your attention to the subject of the drainage of the metropolis?—I have.

2426. Have you examined the plans and sections deposited by the promoters of this Bill?—I have.

2427. Have you heard the evidence given before the Committee?—I have.

2428. I believe you prepared, or caused to be prepared, this large plan (*producing a Plan*)?—Yes.

2429. The sewers or tunnels are coloured green, are they not?—The sewers proposed by the promoters of this Bill are coloured green.

2430. I believe it also shows the scheme proposed by Mr. Forster, the late engineer of the Commissioners of Sewers?—It does.

2431-36. How is that coloured?—Mr. Forster's scheme was composed of two sewers, a high-level sewer and a low-level sewer; the high-level sewer is coloured red on that map, and the area drained into that sewer is also coloured red. Mr. Forster was the late engineer to the Commissioners of Sewers. The low-level sewer is coloured blue, and the area that drains into that is blue also.

2437. Mr. Forster is dead?—Yes.

2438. Having considered the plan and heard the evidence (you are aware it is recited in the preamble, "That it is expedient that powers should be granted for more effectually draining and cleansing the city of London and the parts adjacent thereto"), will this scheme more effectually drain any part?—In my opinion it does not improve the drainage at all.

2439. The tunnels will receive only that which has been already drained?—That is so.

2440. For the purpose of drainage, does the proposed tunnel and the proposed works supply any effectual method, any more than is drained by the present system?—They do not.

2441. It makes no difference in the drainage?—No.

2442. Now, with respect to the cleansing the city of London and the parts adjacent, point out on the map the area that will not be affected by this measure, the sewers of which will not discharge into the tunnel?—The sewers on the north side which would not discharge into this sewer, and, as I understood it in the evidence, were not intended to be conveyed into this sewer, are

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the Stamford Brook, including Hammersmith Creek, draining Acton, Turnham Green, and Hammersmith; the Counters Creek, draining Notting Hill, Kensington, Earl's Court, and Chelsea; the sewers called Church-street, Queen-street, and Smith-street, each having outlets into the Thames, and draining Brompton and Chelsea; the Ranelagh, draining Kilburn, Paddington, and Pimlico; and the King's Scholar's Pond, draining Portland-town, Edgeware-road, Oxford-street, Piccadilly, and Pimlico. Some portions of these two last sewers are uncovered, and, as uncovered, were the subjects of serious complaints to the Commissioners of Sewers.

2443. You have gone through those that are excluded?—Yes; I understand the scheme does not extend to them, and it was not intended that this tunnel should ever take the drainage from those districts.

2444. The districts forming part of Marylebone and Belgravia were excluded?—Yes, large portions.

2445. And all districts of the metropolis westward of this division?—Yes.

2446. On the south side all the districts westward of Vauxhall, how would it be with them?—They would be in the same position.

2447. Clapham, Wandsworth, Putney, Barnes, and Richmond, would they be in the same position?—Richmond, Mortlake, East Sheen, and Barnes, Putney, Wandsworth, Merton, Mitcham, Croydon, Battersea, and Clapham.

2448. *Committee.*] How far does the jurisdiction of the Commissioners of Sewers extend?—The coloured portion on that map shows the rated area: the jurisdiction extends beyond that.

2449. What is the farthest point?—Twelve miles round London. I think all land draining into the Thames within that district.

2450. Mr. *Henderson.*] Pray, are there any or many sewers that have yet to be made within your district?—A very large number.

2451. Give us the number of miles of sewers that are necessary for the drainage?—There are near 1,000 miles of sewers urgently required in this metropolis within the rated area.

2452. *Committee.*] What is the amount of sewers existing in the metropolis; state the length?—Yes; taking new sewers, old sewers which require reconstructing, defective sewers from other causes, and open ditches which receive sewage, about a thousand miles.

2453. Existing?—Yes.

2454. And another thousand miles required?—That thousand miles includes the reconstruction of some sewers that are now so defective that they need reconstructing. For instance, under Portman-square, Baker-street, and some such places, the sewers require reconstruction; they are worn out; I name them among many others that I could enumerate.

2455. Mr. *Henderson.*] Do you know what is about the income of the Commissioners of Sewers, in round numbers?—A 6*d.* rate will raise about 200,000*l.* a year.

2456. I believe the rateable property is nearly 8,000,000*l.* or 9,000,000*l.*?—Yes, a portion of that 9,000,000*l.* being rated as land at one-fourth.

2457. Are your existing funds sufficient to enable you to make these additional necessary sewers?—When I tell you that a rough estimate lately made of the cost was about 2,000,000*l.*, you will see that it is not.

2458. *Committee.*] Two millions for what is required?—Yes, for the construction of sewers for drainage purposes.

2459. Mr. *Henderson.*] Sewers that the Metropolitan Commissioners would make if they had the means?—Yes.

2460. Do you consider those sewers material and important to the health of the inhabitants?—They are very important.

2461. Have you considered the sanitary question as to the effect of the river in its present state receiving all the dejections?—I have.

2462. Do you believe it is more important to the health of the metropolis to have the drainage complete, or to have the river purified?—However desirable it may be to purify the river, I am convinced it is very much more important to drain those localities which are at present without drainage. I may perhaps follow that up by stating, that the Commissioners of Sewers receive deputations, and memorials, and complaints of the want of sewers and drainage, at every court they hold, and I do not remember one complaint (with one exception; I remember one complaint, and only one) of the offence of the sewers in the river.

river. That was at Essex-street outlet; there was a boat pier there, and when the complaint was made to the Commissioners of Sewers, they directed me to prepare a plan for laying down iron pipes from the wharf wall down below low-water mark to prevent the sewage from being exposed, so that it should be under the river, which I believe would have cured that complaint; but the Commissioners had so many more urgent demands upon them at that time for additional sewers, in districts requiring drainage, that the Commissioners of Sewers have not been able to carry out that work.

2463. *Committee.*] That application was made about two years ago at Essex-street?—I think it was first made two years ago; it was under consideration also about a year ago.

2464. Mr. *Henderson.*] The Commissioners of Sewers have been obliged to refuse many of these reasonable applications for sewers for want of funds?—They have.

2465. You said that Mr. Frank Forster, the late engineer, prepared a scheme for the conveyance of a portion of the sewage water?—Yes, he did.

2466. In that there was separation of the drainage in the high and low levels?—There was.

2467. From the high level, would it not be so that the water might be conveyed away by gravitation and natural discharge?—Yes. That plan, I should state, received generally the approval of the late Commissioners of Sewers; but the present Commission have referred it to their consulting engineers, Mr. R. Stephenson and Sir W. Cubitt, to examine into it thoroughly, which they are now about, and which I have no doubt will be made as perfect as any such plan of interception can be, by them. The main features of that plan are, that the red line intercepts all the sewage from the high ground, and it descends by gravitation to the outlet at Barking Creek, whilst the sewage upon the low-level areas will have to be pumped at the River Lea into a high-level sewer, and will then descend with it to the outlet by gravitation also.

2468-9. You have examined the scheme of the promoters of this case, for the north side; is that more or less comprehensive than that of which you have spoken, Mr. Frank Forster's?—Much less comprehensive.

2470. *Committee.*] Both were plans for intercepting drains?—Both which?

2471. Mr. Forster's and this.—Yes.

2472. Mr. *Henderson.*] What is your opinion, as an engineer, as to the relation between these two plans; was Mr. Forster's better than this or not?—I do not consider that Mr. Forster's would effect the total interception of the sewage from the Thames, but it would do so to a greater extent than the scheme proposed by this company.

2473. What would the proportion of the annual cost be; would that be greater or less?—The annual cost of the proposed sewer must be greater, because it proposes that the whole of the sewage should descend into the sewer, and be lifted by steam power, whereas that which would flow by gravitation would cost nothing for lifting, and be more certain in its action.

2474. You would do by gravitation much of what is here done by steam power?—Steam power is always expensive and uncertain.

2475. *Committee.*] Do you consider intercepting drains essential for a good system of drainage for the metropolis?—No, certainly not; I think it has nothing to do with the draining of the metropolis.

2476. Mr. Forster did?—No.

2477. Not when he wrote this report?—I believe not.

2478. What was his object?—Interception of the sewage from the river.

2479. Mr. *Henderson.*] Perhaps you will explain how the drainage is already performed by the sewers?—Yes; I will explain why I think it will not effect the drainage. Any sewer, to carry off the drainage from a district, must be of sufficient capacity to carry all the sewage and drainage that falls upon that district; if it will only carry off a portion, you cannot depend on that sewer, therefore you must construct other sewers upon which you can rely; therefore you must complete the drainage of London, independently of any such scheme; that will not assist it.

2480. *Committee.*] Did not the Commissioners of Sewers refer to Mr. Forster some question regarding the drainage of the metropolis, for him to report on, in 1851; have you seen that report?—Yes.

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2481. Did they not refer to him some questions to report upon?—Yes.

2482. Was not one of those questions to provide a scheme by means of intercepting drains, for so much of the sewage of the north of the Thames as admits of being so carried off?—Yes.

2483. At any rate, in 1851, they considered that a desirable object?—They did.

2484. Or they would not refer to their engineer to report on it?—I do not say now that it is not a desirable object; I say that the object then, as I understood it, and what the public cried out for, was the interception of the sewage from the Thames; it was considered desirable, and Mr. Frank Forster was instructed to prepare a plan for effecting that object. I am aware that the word drainage has been very much mixed up with the question, and it has led to some misapprehension respecting it. What I mean by drainage is the removal of soil, the rain-fall, and the wet subsoil from the dwellings, wherever it goes to; that is what I understand by drainage.

2485. Mr. *Henderson.*] You distinguish, then, between drainage and interception of drainage?—Yes.

2486. *Committee.*] The question to you was, whether Mr. Forster's plan was not constructed with a view to the interception of the sewage matter in its descent to the Thames?—It was by the interception of it from the sewers.

2487. You were understood to say that was not Mr. Forster's object?—I did not mean to convey that; that was distinctly the object of it; not to improve the drainage of the metropolis.

2488. In fact, not to carry off all the rain-fall?—No; that is not what I mean. Supposing a district to be without sewers, and a tunnel sewer running below it into the river, it would not do to lay down a sewer from that district, which would carry all the water which falls upon it into the tunnel sewer, because the tunnel sewer would not carry off the storm and flood waters that would go into it; the flood water would therefore flow back upon the district, therefore that district is not drained.

2489. Supposing the present plan to be carried into effect, the drainage would remain the same as it does now?—That is my opinion.

2490. No more would pass through the sewers which they intercept than passes now?—Rather less; inasmuch as the tunnel sewer takes a portion.

2491. Up to the point of junction, the sewers would remain precisely as they are now?—Yes; the quantity taken off by the tunnel sewer is so small as compared with the quantity that falls upon the metropolis, that on the north side I think it is in this proportion; the quantity it is capable of carrying off is about 180th part of that which is to be provided for. Now, if I extract 180th from each of the sewers, it is unappreciable when I am dealing with a variable quantity; therefore those sewers must be constructed of the same size when this tunnel sewer is made as they are now.

2492. *Committee.*] Did you not say that a thousand miles of sewers are now existing, more or less perfect?—Yes.

2493. And there is a large portion of the metropolis not drained?—Yes.

2494. So that another thousand miles of sewers, including the repairs, are required?—Yes.

2495. Do I understand you now to say, that it is desirable that not only the thousand miles that now drain into the Thames should go on running into the Thames, but to that another thousand miles of sewers should be added, and that that should also run into the Thames?—No, I do not mean to convey that.

2496. We understood you to say that the primary application of the resources of the Commissioners ought to add a thousand new miles, and those must have drained into the Thames; and would not that have been the consequence, that in addition to the sewage now running into the Thames, you would have superadded a thousand additional miles of sewage?—I did not say so, as recommending that they should run into the Thames; I did not say it was necessary that they should run in; but I say they must be of sufficient capacity, if they are to drain all, or they do not effect the object.

2497. Where are they to drain if they do not drain into the Thames, or into some artificial system like that proposed?—That is a question of capacity.

2498. It is the capacity of terminus?—Yes.

2499. What is the outfall of your thousand miles of new drains?—Either for that

that you must have a tunnel of a sufficient size to take all their contents, or they must go into the Thames.

2500. Mr. *Henderson.*] Suppose you have a thousand miles of additional tunnel draining into the Thames, would that be an important advantage to the present drainage?—Yes.

2501. Do you anticipate any material evil from the discharge of this thousand additional miles, when they are made, into the Thames?—I think that evil has been very much exaggerated, and I think it is very much less than the benefit; not to be compared to the benefit which will be conferred on the public by the drainage into the Thames.

2502. With respect to the economy of an undertaking such as this tunnel: is it, or not, expedient to carry off the sewage separately from the high level?—I think it is very desirable.

2503. I believe you are aware that plans have been devised for making the sewage of large towns available for the purpose of manure?—Yes; I am.

2504. Do you know whether any satisfactory experiment has ever yet been made on a large scale as to the value of sewage water?—I have not heard of any.

2505. Do you know whether any permanent or safe plan has yet been adopted for its use?—I have heard of none. I should state to the Committee, that some six weeks ago I went down to Leicester to see Mr. Wicksteed's works, and I found he was there receiving the contents of one sewer, and converting it into manure. I saw the operation performed; and he told me he was about to construct sewers there to convey the sewage into his tanks, and convert it into manure; but at present he could not say anything very positive on the subject.

2506. *Committee.*] This one sewer took all the existing sewage of a portion of Leicester?—No, only a portion of it; they are about to convey the whole sewage to one reservoir, and convert it into manure. I had a conversation with Mr. Wicksteed about the drainage of London, and he stated to me he had very much modified his views. He now thought the best plan would be to collect two or three sewers in London, and in that way convert them by different apparatus into sewage instead of collecting them all in one.

2507. Mr. *Henderson.*] Direct your attention to the present project before you; what have you to say to it as a work; first, what do you think of the plan of transmitting all the contents of the sewers of London into one main drain?—I think that is very objectionable.

2508. State your objections; first as to the repairs?—The repairs could not be carried on in that sewer without diverting the drainage again into the river. The connexion of a number of low-level sewers in the low district, would, I think, be a dangerous operation.

2509. *Committee.*] The connexion with the main sewer, do you mean?—Yes.

2510. Mr. *Henderson.*] In case of accident?—In case of the tunnel sewer being full; the water in the high-level sewer would endeavour to find its level; and would flow back up the low-level sewer into the flat districts, and be apt to flood them; that is assuming it to be high water in the Thames during rains. There were two methods proposed of obviating that; Mr. Gibbs' method was to contract the inlets, so as to graduate the quantity of sewage flowing into the sewer; but that I am afraid could not be done, because in cases of floods those inlets would be under pressure, and then they would discharge a larger quantity of water. From some of the large sewers during floods these inlets would deliver twice as much as they would when only just filled; the water would be forced by the head of water through the orifice. Another safeguard proposed was that of penstocks, so that when the tunnel sewer was filled, as we spoke of, a man should be placed at the penstock to close it, and prevent the sewage flowing back. Now that, it appears to me, is a very uncertain operation, because it seems left to the man's judgment, when the rain is sufficiently heavy, to close that sewer, and when he should open it again, and that man must always be on the look-out, always watching for it.

2511. *Committee.*] At present, with a high tide, the sewage water is sometimes forced up the sewers?—It is.

2512. And what you fear is, that something of the same kind might happen to this sewer?—I should state, that at present the waters from the high districts, (which are represented above) fall down into the low districts, and there during high water the sewers should be large enough to act as reservoirs; and they

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should be so calculated that they will just contain the greatest quantity of water during floods.

2513. Do you mean they never do flood the districts?—I do not mean to say that. In Surrey and Kent the quantity of sewers have so increased, and the quantity of drainage so increased, that they have surcharged the present outlets, and want more. I was going on to say, that those sewers are calculated to contain during high water the quantity of water that flows into them; but if a sewer from a high district is connected with the tunnel sewer, the flood waters would naturally flow back in the tunnel sewer into the low level districts, until the water in each rose to the same level.

2514. How would these evils be increased by an intercepting sewer at a much lower level than the Thames; why would that increase the flowing back?—Because it connects two sewers which before were disconnected from each other; and therefore the water in one may be much higher than in the other; the water in the one would flow back into the other until it filled it and reached its equilibrium.

2515. You are assuming that the pumping engines are not working?—I am assuming that the engines are not anything like sufficient for the quantity of water coming down during rain.

2516. You must be assuming that the pumping engines cannot keep the tunnel from being gorged?—I will explain myself better directly: the pumping engines, as we have been informed, are intended to be capable of pumping 20,000 cubic feet of water up; but in London we have rain to the amount of two inches per hour, which would give 3,600,000 cubic feet per minute.

2517. Assuming it got into the lower tunnel?—Yes; I am not aware how it is to be kept out.

2518. It is to go in its natural channel into the Thames?—But the sewers which receive it are connected with the tunnel; I cannot quite understand how it is to be kept out.

2519. That will depend on the size of the connecting sewer, will it not?—No; I have just said respecting the size of the connecting sewer, that the quantity a sewer of any size will deliver, will vary as the square root of the head of water or pressure on it, therefore you cannot graduate that sewer so that it will only deliver a certain regular quantity.

2520. You may, as you descend in the tunnel, narrow the aperture of the connecting sewer, and so far be counteracting the effect of the pressure resulting from water higher up, or, as Mr. Gibbs said, you may always contrive that the water shall never be allowed to gorge the tunnel to its full extent?—If you have some apparatus by which you reduce the aperture, whenever there is a flood you can do so.

2521. Mr. *Henderson.*] If you leave a large portion to pass out into the river you diminish what is in the tunnel; in this scheme that is before the Committee reliance is placed on steam power to lift the whole that comes from the tunnel?—Yes.

2522. Do you think that expedient?—No, I think not.

2523. Why not?—Steam power is both expensive and uncertain.

2524. What would be the result of staying, by accident or otherwise, the exercise of the steam power to the safety of the tunnel?—The tunnel then, in my opinion, would fill up again until the sewage reached the level of the sewers above it, and the sewers would discharge again into the river; the tunnel at that time would be depositing the contents of the sewers collecting in it, and it would be subject to an enormous internal pressure.

2525. *Committee.*] Do I understand you to say that all means of lifting by steam power are objectionable?—I think it is to be avoided as much as possible.

2526. Then any low-level sewer would on that system have to be provided for?—I think it must be resorted to sometimes on low levels.

2527. It will be open to the objection you state of steam power being required?—Yes; it is an objection; avoid it, if you can.

2528. If you have a low-level sewer, you cannot avoid it?—No.

2529. Mr. *Henderson.*] You think as much as possible should be carried by gravitation from the high level?—Yes.

2530. What do you think of the pumping station of the company, as proposed by this scheme; is it a judicious place?—No, I do not; I think, if the pumping station

station had been placed at the River Lea, it might have been so arranged, pumping there to a high level, and descending thence by gravitation to Barking Creek, as to connect with the high-level sewer to which I have alluded.

2531. Would that have saved the construction of a portion of this tunnel?—It would have saved the construction of about four miles of tunnel.

2532. What is the depth on these four miles below Trinity high-water mark?—Forty or fifty feet.

2533. What effect has that circumstance upon the sewers with respect to internal pressure?—It produces an enormous pressure, equal to about 30 or 40 tons to the foot-run.

2534. Then that increases the risk of accident?—Yes; in tunnelling for a sewer it is impossible to excavate the ground in the exact form of the sewer; and the ground can never be replaced behind it as firm as that removed. I think, then, when there is this internal pressure in the arch, it will be apt to crack the joints, press back the brickwork, and allow the water to get behind and soften it, and thereby make the tunnel subject to frequent repairs.

2535. When repairs are going on, and men are in the tunnel, would it be necessary to divert the sewage into the Thames, as at present?—It would.

2536. Thus much for the tunnel. For how many days, as you compute, would the sewage continue to flow into the Thames, as at present?—I think that something near 100 days in a year the sewage would continue to flow into the Thames.

2537. *Committee.*] Supposing the scheme is carried into effect?—Yes.

2538. Mr. *Henderson.*] That would be in addition to this period during which the repairs had to done to the tunnel?—Yes.

2539. *Committee.*] Now about the repairs; have you ever constructed any large sewers?—I have, a good many.

2540. Where; in London?—Yes.

2541. Which is the largest you have constructed in London?—I constructed a part of the Fleet,

2542. You repaired it?—No, I constructed the upper end.

2543. What size have you constructed that?—Six feet diameter.

2544. Of what shape?—Circular.

2545. How long is it since you constructed that?—About a year ago.

2546. Has that required any repairs since it was constructed?—No; it has never been subjected to that pressure; it is not similarly circumstanced.

2547. Have you repaired the other part of the Fleet?—The Fleet has never been subjected to that pressure.

2548. Answer the question?—I have repaired it.

2549. Do you know when it has been repaired before, the Fleet Sewer; how many years has it gone without repair?—I cannot answer that question; it is very much out of repair now, and we are frequently repairing it. Sometimes houses fall in; the last time, some stables built over it fell in.

2550. That is the oldest sewer in London?—I think some in the city are older than that.

2551. Have you constructed any tunnel, that has been subjected to pressure, where the results have been those that you predict would result from the pressure that this would be, or anything analogous to it?—No. I am not aware that any such tunnels have ever been constructed.

2552. Your opinion as to the necessary repair is speculative to that extent; you have no practical instances?—No, I cannot say I have.

2553. Mr. *Henderson.*] You have never seen such a tunnel as that proposed; but speaking as an engineer, that is your opinion?—That is my opinion.

2554. I believe you compute the present sewage on the north side of the river at 9,100,000 cubic feet per day?—Yes.

2555. That flows unequally during the day?—Yes; one half flows in about six hours; that being an average upon the six hours, it flows a part of the six hours at the greater rate, and part at the smaller rate.

2556. Have there been known two inches of rain in London in an hour?—The increased flow continues about eight in the morning, continues increasing up to eleven or twelve o'clock, and then decreases down to about two or three o'clock.

2557. There have been known to fall in London two inches of rain in the hour?—

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hour?—Mr. Glazier, of the Greenwich Observatory, has forwarded to me a great number of experiments made by him, from which I find that it is not an unfrequent occurence that two inches of rain should fall in an hour.

2558. Assume that a hundredth part of an inch of rain per hour falls in addition to the maximum flow of sewage passing into the sewers, what would that give?—For 47½ square miles, it would give 19,132 cubic feet per minute, which, added to 12,638 cubic feet of sewage, would give 31,770 cubic feet per minute. The quantity that the sewer would carry off may be taken at what the promoters' engineers put it at. The sewer would be too small for that quantity; I do not say that that is the quantity to be carried off; it is a question of degree. Thus the more you can carry off, the less frequently will the sewage go into the river; the less you carry off, the more frequently. I think if it were capable of carrying off that quantity, still from 80 to 100 days the sewage mixing with the rain-fall would go into the river. The average of the last four years gives 150 days per annum on which rain falls.

2559. What horse power would be necessary to raise to the height that we heard of that quantity of water?—About 3,500 horse power.

2560. You have spoken hitherto of the north side; will you now go to the south side; do any of the objections that you have stated apply to the tunnel on that south side?—Yes, I think they do; on the south side there is a much larger area to drain, and a much smaller tunnel to drain it.

2561. From Deptford Creek to the outfall in passing Greenwich is the line of the company at such an elevation as to render it impossible to intercept the drainage of that district?—Yes, it is at such a level that it will not intercept the drainage of Greenwich.

2562. Then the whole of the drainage of that district must continue to go into the Thames?—Yes.

2563. Upon the principle you have spoken of, the intention of having the low level, is it equally applicable to the south side?—Yes; I think that is very important; the waters at the high levels at the present time flow into the low level and flood those districts; therefore it is very desirable to relieve them from those waters by diverting them, and carrying them off by gravitation.

2564. What is the area of the high level on the south side?—The rated area is about 40 square miles.

2565. And the lower?—21½.

2566. *Committee.*] You say these higher districts now send down water, which floods the lower districts?—They do.

2567. And it is very desirable to prevent that?—Yes.

2568. For the purpose of preventing that, must there be an intercepting drain?—Yes, of sufficient capacity.

2569. Then it is very desirable to have some intercepting drain there, for the purpose of protecting the lower level districts?—Yes, I think very important.

2570. Mr. *Henderson.*] Is the provision made by the line of sewer sufficient in extent or design?—No; this line is a low-level sewer, which receives the contents of the sewers, or at least receives a small portion of their contents, after they have descended into the low-level districts.

2571. Tell us what quantity of sewage is now daily discharged on the south side from the low-level area per minute?—I take that at the computation as given; but that at present is not very satisfactory. Mr. Hawkins made gaugings in 1844 on the north side of the river, and he ascertained by those gaugings how many cubic feet per minute were given by urban area, and how many by suburban area; and he then applied that average to the south side, taking it at so many cubic feet per mile per acre upon 15 square miles. Now, the south side has since that increased to 61½ square miles, and in taking that data (I believe it is very much under the mark), it gives me 4,166 feet per minute, taken during the maximum flow.

2572. During six hours of maximum flow?—Yes.

2573. Do you think provision ought to be made for a larger flow?—Yes, I think it ought. I should state, that to get that data more efficiently, the surveyor of the City Commissioners is now making gaugings of the sewers in the city, and as I believe it to be very important in considering a scheme of interception, I have reported the fact to the Metropolitan Commissioners of Sewers, and requested them to authorise me to ascertain that more correctly.

2574. Apply to this side what you did to the other; take the present maximum

mum flow?—The size of the sewer is clearly so inadequate to the drainage of 60 square miles, that I have assumed that it is not intended to be applied to it; that it is supposed that something will be done with that; and I have made my calculation referring only to the low districts of 21½ square miles. I take the sewage as given, 4,116 cubic feet a minute, and a hundredth part of an inch of rain per hour, which mixed with it, gives me 12,187 cubic feet per minute.

2575. Add the ordinary flow to that?—That is the total; the average flow during the six hours gives me 4,116 feet a minute; rain, 8,671; total, 12,187.

2576. What quantity of horse power would be necessary to raise that quantity the height proposed?—About 900 horse power.

2577. *Committee.*] Had not Mr. Forster a scheme also for draining the south side of the Thames?—He had.

2578. Was it a more extensive scheme than this?—His scheme was never completed.

2579. As a plan?—It was, as far as it was laid down. The low-level sewer was eight feet. It has never been laid down.

2580. Is that his plan; his report upon it?—He never went so far into detail upon it in his report. He has not in his report given the size.

2581. But he gave the cost?—Yes, he did.

2582. Did he give that without knowing the size?—He had considered the size, and I believe it was eight feet; but I do not speak certainly upon that point; he contemplated an intercepting sewer, which is not in this scheme.

2583. And also a lift?—Yes; when I say intercepting sewer, I mean a sewer discharging by gravitation, and also a sewer to be lifted.

2584. That was in 1850?—It was.

2585. Then at that time, in January 1851, the Commissioners of Sewers seem to have contemplated two intercepting sewers; one on the north, and one on the south side of the Thames, and lifts?—Yes, they did.

2586. Mr. *Henderson.*] Did not the Commissioners of Sewers invite and receive a great number of plans from a great number of persons?—Yes.

2587. I believe 100 plans?—Yes.

2588. Were they not considered by Sir William Cubitt and Mr. Robert Stephenson?—Yes.

2589. The plan of Mr. Frank Forster was not finally adopted; it was under consideration?—I believe it received the approval of the then Commissioners.

2590. As to the uniform rate of inclination of the tunnel, what is your opinion as an engineer upon that point?—I think it is unnecessary; that it is undesirable to have a uniform rate.

2591. What effect has that upon the original and permanent cost?—If you have a uniform rate, the same rate of four feet a mile, for the sewer, five feet in diameter will give a smaller velocity than a 10 feet sewer with the same fall; therefore I think it is desirable to economize, when you get to a large sewer, the lifting power as much as possible.

2592. You would prefer a uniform velocity to a uniform inclination?—Yes.

2593. Now, can these sewers be made available as district sewers?—No.

2594. Those proposed by the Company?—No; they do not assist drainage at all.

2595. Are they large enough to afford outfalls where you require new outfalls?—No; those districts which require new outfalls must have outfalls built, whether they go down to Barking Creek or at London Bridge; they must be built of sufficient size to some place where they can discharge their contents, independently and irrespective of this tunnel sewer.

2596. If the scheme is complete, will it in any way improve the drainage of the metropolis?—I think not.

2597. Will it effect any saving to the ratepayers?—No, not in the slightest degree.

2598. Do you know any benefit that will be derived from this work in districts that have no sewers?—No, none whatever.

2599. Supposing this work complete, does it impose, of necessity, the adapting all future sewers to it?—Yes, provided all the sewage is to be discharged into it; they must be adapted to it, no doubt, and must be connected with it.

2600. Do you anticipate from the proposed works any embarrassment in

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the drainage of the metropolis?—That fact would, to a certain extent, embarrass it.

2601. Have you visited the works of Mr. Wicksteed?—Yes.

2602. And that is a mere experiment?—Yes; it is likely to be carried out immediately for the whole sewage of the town.

2603. Did it appear that the sewage water would be more advantageously dealt with at the mouth of the sewer than if they carried the contents to a distance?—I do not suppose it would affect that at all.

Cross-examined by Mr. *Hodges*.

2604. Did you succeed Mr. Frank Forster?—Not immediately.

2605. When did you become engineer to the Commissioners?—I was the engineer of one of the districts under Mr. Frank Forster, and about six months ago the Commissioners appointed me as their engineer.

2606. Were you associated with Mr. Forster when he prepared these plans, then?—No, I never had anything to do with those plans.

2607. Are you aware that the first plan suggested was the plan of Mr. Wicksteed?—Yes, I believe Mr. Wicksteed was the originator.

2608. You mention it in your report?—Yes.

2609. Do you know what the size of Mr. Wicksteed's sewer was?—No, I do not.

2610. Do you not know it was about the same size as that which is now proposed?—I think that is very likely: I cannot say positively at this moment.

2611. Somewhere thereabouts?—I think it is very likely; but as I do not know, I cannot say.

2612. How soon after Mr. Wicksteed propounded his plan did Mr. Frank Forster propose that lower sewer that we have heard of?—As I understood yesterday, Mr. Wicksteed proposed his plan in 1845; Mr. Forster's plan came out in 1850.

2613. What was the size of Mr. Forster's lower level sewer?—Ten feet in diameter, I think.

2614. It took very nearly the same direction as Mr. Wicksteed's, did it not?—I really do not know Mr Wicksteed's; I can compare it with the present one, if you say that is the same as Mr. Wicksteed's.

2615. The present sewer also takes pretty nearly the same course as Mr. Forster's lower level sewer, with some slight deviation?—Very nearly; with some slight deviation from the Victoria Sewer to the River Lee.

2616. Are you not of opinion that the variations proposed here are desirable; that this is rather a better course than Mr. Forster's?—I think in point of direction there are some improvements, and I think there are some objections.

2617. But it was part of Mr. Forster's scheme to pump up the contents of that low-level sewer at the River Lee?—At the River Lee, not at quite so great a depth as proposed by the company.

2618. Do you know what amount of steam power he proposed to use?—No, I do not at this moment; it is stated in the report, I think.

2619. I think I understood you to say that it is necessary now to lay out nearly two millions of money in completing the sewage of London, irrespective of this great tunnel sewer?—Yes.

2620. A thousand miles of new sewer is required, at an expenditure of 2,000,000*l.*?—Yes.

2621. And you are clearly of opinion that should be done before any money is laid out in a low-level sewer?—Yes; I am quite satisfied that any one acquainted with the requirements of the metropolis must come to that conclusion.

2622. That is your conviction, at all events?—Yes.

2623. Do you think that the Commissioners have arrived at the conclusion that this system of interception should be carried out or not?—I stated that the Commissioners have referred that subject to their consulting engineers, who are now considering it.

2624. I see a report which bears your name, and at page 24 you say, "We assume it to be determined that the interception, if practicable, ought to be accomplished"?—I have not a word to say against the interception; I simply state, however important it may be, or however desirable, I think it much more important to drain those localities that are now without drainage, where the people are really suffering from a want of it.

2625. I suppose

2625. I suppose practically that will be put off to a very remote period of time, when this intercepting sewer proposed by Mr. Forster, or a similar one, will be carried out. How soon do you expect to possess the 2,000,000*l.*?—That is a question I cannot answer.

2626. Have you borrowed any money for the purpose of sewage since you have been connected with the Commission?—Very little.

2627. And the cases where you have borrowed money, do you know what rate per cent you have paid for it?—I do not; that does not come within my department.

2628. Do you not know that it is 4 ½ per cent.?—Yes, I believe we pay something of that kind.

2629. You go on the principle of paying off a portion of the capital every year?—I am not aware of such a requirement.

2630. Do you not know that it is spread over a period of 25 or 30 years?—I do not think anything of that kind is imposed on the Commission.

2631. I think you tell me that Mr. Forster's low-level sewer was 10 feet; you provided there that the surplus waters in flood time should go into the Thames?—Yes.

2632. By means similar to those proposed by the present company?—Not quite so.

2633. In what respect do they differ?—Because the upper sewer would always have been discharging and preventing a large portion of sewage from coming down into the low districts, which, to my mind, is a great advantage; I think if that upper tunnel sewer were constructed first, relieving the lower districts from sewage, it would facilitate the construction of the lower one.

2634. I believe it was contemplated that the lower sewer would sometimes overflow when floods came in?—It must have been.

2635. Do you not believe that he proposed a similar mode of getting rid of those flood waters as the mode proposed by the company who promote this Bill?—That was a work that I had nothing to do with at the time, therefore I do not know what provisions were made.

2636. You believe Mr. Forster had some provision of that sort, if it was not to take the whole flood waters?—I suppose he would consider that necessary.

2637. In taking your rain gauge, point out to me the extent of country you included in your calculation; with regard to rain, you took in the whole of that coloured on the north side, including Hammersmith?—Yes, I included the whole of that coloured area, except those two small portions coloured blue.

2638. It is made on the calculation of the rain-fall extending to Hammersmith, Kentish Town, Highgate, Kilburn, and the whole of that country?—Yes.

2639. Upon the supposition that the rain-fall would flow into this tunnel?—On the certainty that that rain-fall would flow into the existing sewers and mix with the sewage, and unless you construct a fresh set of sewers all over those districts to receive the rain-fall, and prevent its mixing with the sewage, you must provide for it.

2640. Have you included in your calculation the rain-fall at Hammersmith?—Yes.

2641. How could that fall into this sewer by any possibility?—Hammersmith you are aware is covered with buildings, and the population of Hammersmith, and all round London, is increasing very rapidly, and the demand for sewers is increasing, and they are being built by private builders, and sewage is being conveyed into that Hammersmith Sewer, and into the Counter's Creek Sewer, and into the Ranelagh Sewer, and those two last are as offensive as any other sewers in London.

2642. Have you taken into account the country beyond Hammersmith; surely all that would go into the Thames at that point?—Those are the main drains of that district to take the sewage off; everything that comes in those districts passes into those sewers; if you are to separate the sewage from the rain-fall, you must construct a fresh system of sewers for that purpose, which involves an enormous work.

2643. You have never found any difficulty in draining into the Thames; do you mean to say you have no sewer discharging itself between Fulham and Hammersmith?—Yes, I have no doubt there are minor sewers; there are a great number of minor sewers discharging all along the river.

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2644. Would not a great quantity of the rain-water find its way into the river by means of those sewers?—Those sewers also receive house drainage.

2645. It is sufficient for me that you have included the whole of that in your calculation?—I have done so, because I am satisfied that it is absolutely necessary to provide for it; if you propose to divert the sewage from the River Thames I cannot see how to get over it.

2646. Now on the south side, in your calculation of the rain-fall there, you have included Richmond, Mortlake, Wandsworth, Battersea, Kew, the Wandle, and the Ravensbourne?—Yes, I have.

2647. You calculate that the waters that fall there would flow into the south tunnel?—Yes, and I will tell you why; Richmond has lately been drained, and the sewage now descends into the ditches just below it, there being at present no proper outfall; and one of the sewage manure companies, I believe Mr. Higgs, has lately applied to the Commissioners to be allowed to erect his works at Richmond, to manufacture manure there; so I take the Wandle, receiving the drainage first of Croydon.

2648. *Committee.*] Do you mean that the sewage of Richmond is to flow into this sewer that is now constructed?—It was the intention of Mr. Forster to connect the sewage as far as Richmond.

2649. Is there anything in this plan to justify you in saying that it is part of this scheme to take the sewage of Richmond?—No; but according to my notion, if it is to intercept the sewage from the river, it must do it; it requires to do that.

2650. Mr. *Hodges.*] But your calculation of 100 days in the year is based on this supposition?—Yes.

2651. And the steam power too?—Yes, no doubt about it; I consider that the scheme proposes to intercept all the sewage from these sewers, or that it does not attempt what it professes.

2652. You say that you do not believe that this low level would improve the drainage; let me understand what you mean by that distinctly. You have told me that the sewage now, in the case of heavy rains and high tides, is sometimes kept in the sewers a considerable period, and that they act as reservoirs?—Yes.

2653. At that time the sewage does not flow at all; it is penned back in the sewers?—Yes.

2654. Does it not follow as a consequence, that a great deal of miasma arises from the sewers' mouths, through the gratings; those portions of the sewers where the sewage is penned back?—I am not aware that the miasma is worse than at any other time, the sewage being then diluted.

2655. Sewage is getting worse when it is penned back?—Yes.

2656. Have you not had complaints, from the Temple, for instance, in consequence of the dreadful stench that came up from the sewers under circumstances similar to those I have described?—Yes, we have frequent complaints, but not under those circumstances.

2657. Did you yourself go down to the Temple to ascertain whether they were founded on a just cause?—Do you allude to the Essex-street outlet?

2658. Yes?—That was the sewage from the sewer running down on the banks of the river to low water.

2659. That was another ground of complaint?—No; that is the only one.

2660. That has not been rectified?—That has not been rectified, for the reason I gave.

2661. How long do these sewers take to discharge themselves after the flood-waters go off, before they become empty as they were before; are they not five days sometimes discharging themselves?—No, not so long as that.

2662. Three days?—It must be a heavy flood that a sewer has not relieved itself of in three days.

2663. Have you known them take as long as three days to discharge them?—I think on the Surrey side it has been three days before the sewer which was overcharged has completely recovered itself.

2664. During this time the cellars are filled with the sewage in some places?—Yes, to a great extent.

2665. People poisoned?—I am afraid, for want of sewage, that has been frequently so.

2666. This low-level sewer, with a constant flow, would prevent any occurence of

of that kind?—I am afraid not; it would take off 1-900th part of what comes down.

2667. Do you mean to say that you do not believe this sewer is quite large enough to carry off the ordinary sewage of London, and the ordinary rain?—During the ordinary sewage and the ordinary rain that state of things does not apply. You are applying a case when there are floods, when there are heavy rains, and then it comes to 1-900th part.

2668. The moment the flood is over, how long would the tunnel be before it was capable of being discharged again; not three days?—When the flood is over the sewers discharge the main body out into the river, and thereby recover themselves; the sewer would assist in that to the amount I have stated, 1-900th part.

2669. Would not the tunnels in three hours be in a condition to discharge again?—After the three days; after they have cleared themselves the tunnels would be working as before.

2670. In how many hours?—If the tunnel carries off 1-900th part, it will not assist materially in emptying those sewers.

2671. Taking your own average; you state that for 265 days in the year the tunnel would be running?—Yes; you must remember I have given you what I consider to be the present amount of maximum flow. I think with your own engineer, that provision should be made, seeing that the sewage has increased so rapidly up to the present time, I think provision should be made in the size for double the quantity.

2672. How large would you make the sewer, if you made it?—That I am hardly prepared to say at present; the larger you make the sewer the more you assist the interception. I am only stating now what amount of interception will be effected by the sewer.

2673. I should like to press you on what the proper size of the sewer would be?—I am now instructed to consider the scheme by Mr. Stephenson and Sir William Cubitt; and therefore I think it would be premature for me now to advance an opinion on it, because I have only just commenced the inquiry.

2674. Have you no thoughts on the subject?—Yes; I shall be happy to tell you what different sized sewers will carry off.

2675. I understand you see little probability of making the sewer at all; if it were made, what size should you make it?—That would be coming to a conclusion which I do not think I am justified in stating at the present time.

2676. Larger or smaller?—I should, I think, recommend it larger.

2677. How much larger?—That is pressing me to give an opinion on a thing which I am not in a condition at the present moment to do, it being governed by a variety of circumstances.

2678. Do you not consider that having this low-level sewer to drain into is an advantage?—I think it is; it intercepts the sewage from the river to some extent.

2679. Is it not an inprovement to the draining of the metropolis to have that low-level sewer?—No; I cannot confound drainage with intercepting sewage from the river.

2680. Would it improve the sewage of the river?—It would to some extent improve the river.

2681. To a very limited extent?—Not to so great an extent as is anticipated.

2682. Do you think it would be any advantage to prevent any sewage going into the river at those two points?—I think it would; it is a question of degree. It is erroneous to suppose that it will intercept it altogether, and I think the advantage derived is not so great as would be derived by laying out that money in drainage works.

2683. You are quite clear on that point?—Yes.

2684. Now I have only one other question to ask you; was there not a contract entered into for one of the sewers proposed by Mr. Forster, on the south side, by the Commissioners for making it?—I believe there was, not for one, but part of one.

2685. That was one at a low level?—Yes.

2686. Where there was to be lifting by steam-engine?—Yes.

2687. Having for its object pretty much the same as that now proposed? Yes.

2688. What was the amount of the contract?—That I do not know.

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2689. The reason it was not carried out was, that you had not the money?—Yes, I believe that was so.

2690. It was a large contract?—Yes.

2691. More than 100,000 *l.*?—I cannot state the amount; I do not remember at all.

Examined by the *Committee.*

2692. Are there not some districts that are below the level of the Thames in the metropolis?—Yes, below the level of high water.

2693. Are there none below low water?—No, none; from six to eight feet below high water is about the lowest.

2694. For draining those is it desirable to have a drain at a low level, or can they be equally well drained without any new drains at a lower level than the Thames?—I am afraid they must be drained without that, on account of the enormous size that will be required if it is to be connected into one drain.

2695. The question was as to those other districts; if they are below the level of the Thames, would they not be better drained by having a drain sunk at a lower level than the river?—Yes, and pumping the contents; if you could take off all that falls from that district, it would; the pumping power is an enormous cost.

2696. What is your opinion as to the sufficiency?—As to the sufficiency, it would, if you could take off all that falls.

2697. As to the cost, you cannot give any information; you are only dealing with the works; you were asked some questions as to the financial position of the Commissioners of Sewers; you said you were not acquainted with that?—I stated the amount the Commissioners raised by rates.

2698. You do not know the other monies they borrow?—I know they are very inadequate; they are about to apply to Parliament to enable them to do what they believe to be necessary.

2699. Can you give some notion as to the appropriation and the application of the 200,000 *l.* a year now between existing sewers requiring repair and new sewers that you are laying down; can you give any rough notion on that subject?—I am afraid I cannot.

2700. How long back was that interview with Mr. Wicksteed?—About two months ago.

2701. You have stated that at present he felt unable to express an opinion as to the success of the enterprise in a commercial point of view?—Yes.

2702. But still that he was about to proceed to collect the sewage of the rest of the town?—Yes.

2703. After having already made some experiment on a portion of it?—Yes; and in about 12 months he thought he should be in a position to give some further information.

2704. After having made an experiment on a portion of it, which he said did not enable him to speak with confidence as to the result, he nevertheless was proceeding to spend money in collecting the residue of it?—Yes.

2705. With respect to the danger you apprehend to this tunnel from the pressure that you speak of, as an engineer, will you deny that the tunnel may be so constructed as to render it proof against any pressure to which it will be subjected?—Yes; but we have heard how it is to be constructed; we heard it is to be 18 inches of brickwork.

2706. You do not deny that such a tunnel may be constructed to preclude the danger that you apprehend from this?—No.

2707. Then, in your judgment, the 18 inches is not thick enough?—No, I think not.

2708. Then if you were undertaking this work on the part of the Commissioners, you would recommend them to adopt a more expensive tunnel as regards the construction of it?—If it was to be subject to that pressure, yes.

2709. What thickness of brickwork, as an engineer, would you recommend?—That must be the result of calculation.

2710. Now will you state what is the pressure; you have not made it quite clear how this enormous amount of pressue results. What would be the pressure, for instance, on the tunnel at the Fleet Ditch; how would that be measured; by what column of water?—A cubic foot of water would give a pressure of 62½ pounds.

2711. You know the depth of the tunnel there, and you know the distance from the mouth of the tunnel; what will be the column of water which will represent the pressure on the tunnel at that point?—I do not quite understand you; will you be kind enough to repeat the question.

2712. You apprehend, and you give the pressure that would in some parts of this tunnel exist; what will be, in your judgment, under any possible circumstances, the maximum amount of pressure upon the tunnel at the Fleet Ditch?—At the present time?

2713. No; assuming this tunnel to be constructed, and assuming any state of things that can result after it is constructed, what would be the maximum pressure that could result?—The pressure would not be upon the Fleet Ditch, but upon the tunnel.

2714. Upon the tunnel at the Fleet Ditch?—Yes, I can tell you that; it would be about 13 tons to the foot-run.

2715. Now, how would that pressure result; what would be the cause of that pressure; assume that the existing sewers are capable of running off to the Thames as they at present do, if the connecting sewer is filled with water?—It would be the column of water.

2716. What height?—That I will give you; about 25 feet; it is not quite so much as that.

2717. Then correct your answer?—There it is about 12 feet 6.

2718. Then do you correct your other answer; what would be the amount of pressure there if the column of water is reduced?—No, I have taken out the heights correctly, and worked out the pressure at different places.

2719. And that pressure would keep increasing, after the tunnel was lengthened, at the rate of four feet per mile?—Yes.

2720. Then there would be a larger amount of pressure at the lower end of the tunnel, and a less amount of pressure at the upper?—Yes.

2721. Then there is no orifice in the last four miles?—No.

2722. Therefore where the maximum pressure exceeds, there would be no opportunity of water being forced back, there being no orifice?—Yes.

2723. Now, we understand that it was in deference to the views of the Commissioners that the tunnel was carried those four miles, instead of being stopped at Bow Creek: was that in deference to your views, or whose views?—I think I can explain that; when Mr. Forster was directed to prepare that scheme, his instructions were to discharge the sewage into the river at such a point that it should not return again to London; and he had some experiments made for some time with reference to the flow of the tides, and he found that it would be necessary to go to that point, and to discharge at that point at high water, to prevent the sewage returning upon him. The sewage at Greenwich would at certain times, even though discharged at high water, or within two hours of high water, return up to six miles above that point, which is near London Bridge.

2724. Now do you, as the engineer of the Commissioners, think that those are sufficient reasons for going on to Barking Creek?—Upon my word, I do not.

2725. In case the commercial part of the experiment were to succeed, there would be no objection to the discharge of the purified water into the Thames at Barking Creek?—I think not.

2726. Assuming that that pumping were to be required in either case?—Yes.

2727. Assuming that the experiment were not to succeed, and you were to throw the impure water of the tunnel into the Thames, might it not be done by pumping, at Bow Creek, and an open channel across that other portion, or a channel on a lower level?—You are aware that they are going to build docks over that district.

2728-9. Would that be an objection to the mode of discharging the sewage water?—No; but it would to having an open channel.

2730. You say, anything that aggravates the lift is a serious objection to the scheme?—Yes.

2731. You would aggravate the lift seven feet?—That is clearly my view, that it would be much better to lift it at Bow Creek, so that one sewer should convey from that point by gravitation the sewage of the whole district.

2732. And even assuming the necessity of a covered sewer there, it would not

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not be a work anything like so expensive as four miles of tunnel, with the highest pressure that will exist in any part of it?—There would be no pressure, or anything of that kind. If ever the high-level sewer is carried out, that must be constructed.

2733. Then in that respect, out of deference to the Commissioners, the scheme has, in your judgment, as engineer of the Commissioners, been rendered more expensive and less desirable?—I was not the engineer of the Commissioners then.

2734. I cannot quite collect from you; do you or do you not recommend that the sewage water of London should be intercepted in its passage to the Thames, or not; taking the expense, and every consideration into account, what is your opinion upon the subject?—That is bringing it to a point. I certainly think that the money will be better laid out in constructing sewage works. I should not recommend money being expended upon that at the present time.

2735. Nor until a very large expenditure had been incurred in another way; two millions of money?—No, I would not.

2736. I want to ask you as to the effect on the Thames of the discharge of the whole of the sewage water, and the effect on the Thames of the discharge of the sewage water in times of flood. You do not doubt that the gathering of foul matter on the sides of the Thames would be very much larger in one case than in the other. Assuming this tunnel to be constructed, and the foulest part of the sewage being carried off, it would very much indeed diminish the amount of foul matter that now gathers on the sides of the Thames?—It would to some extent; you would still have the mud banks.

2737. Even taking your own calculation, that for 100 days the sewage would, with rain-water, flow into the Thames, during the rest of the year the unmixed sewage would be carried away?—Yes.

2738. Now the water that would run into the Thames, and mix with the Thames in times of flood, would be of necessity water very much diluted as compared with the other, from the increase in bulk of it from the addition of pure water?—That would be so after a time; but we find that the flood-water cleanses the sewers, coming down through the sewers. In dry weather a deposit takes place, and when wet weather comes it washes away a quantity of that sewage.

2739. Then intercepting the flood-waters by a high-level drain will in that respect leave the sewers more impure than they are at present?—That consideration I have always had in view as a very important one; and by having a high-level sewer, and gates at the side of it, you could at all times let a portion of the sewage come down with a rush on any line of sewers to the low level, and thereby thoroughly cleanse them.

2740. You admit that the quantity of foul matter which deposits on the banks of the Thames would necessarily be very much diminished by any scheme carrying off so large a portion of the foulest sewage matter?—Yes.

2741. Do steamers now, by their constant passage up the Thames, raise that foul matter which is so deposited, and make the water more foul than it would be if it was not agitated by the steamers?—My own impression is, when it is mixed with the Thames, is not the time when it is perceived; it is when the sewage is flowing from the high-water mark down the banks of the river to low water.

2742. Then at that rate there exists some impediment, of which I am not aware, to carry the mouths of the sewers, as the Temple Sewer is carried, to low-water mark?—It has not been carried.

2743. It has been very much prolonged. Taking your evidence, if the mouths of the sewers could be practically extended to low-water mark, in your opinion it would very much get rid of the whole objection?—I think so.

2744. How is it the Commissioners of Sewers have never done that with respect to some of the most important sewers?—They have done so with the last sewer they constructed, the Victoria-street Sewer. The reason why it has not been done to others is, that they really have not had funds to carry out those drainage works which they are called on to do. The inhabitants of London are willing to contribute a large portion towards those sewers if the Commissioners had the remainder. You asked one question about the shape of the sewers, which I should wish to explain, why our sewers are not circular. They

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are for a different object. Sewers for drainage have generally a small flow of sewage coming down them, therefore it is the object to get the least amount of friction, or the greatest hydraulic mean depth for that small quantity, and have reservoir room above. This sewer would be totally differently circumstanced.

2745. At what point is it that you arrive at the very high pressure you spoke of in some part of your evidence?—The 40 to 50 tons is from Bow Creek to Barking Creek.

2746. During the time you have been connected with the Commissioners of Sewers, what new sewers have been erected?—At the present time we are constructing a large block of works in Westminster, and a large block of works about Drury Lane.

2747. Those are new sewers?—We are continually constructing new sewers. The Commissioners generally ascertain what funds they have to apply to the construction of sewers; and then they direct their engineers to bring up all cases; to report to them which are the most urgent cases, and construct them as their funds enable them to do so.

2748. You say there are a thousand miles of existing sewers; how many miles of sewers have been made within the last year, do you suppose?—I am afraid I cannot tell.

2749. You can give us some idea?—From seven to eight miles.

2750. Within the 12 months?—Yes.

2751. What is the state of that Victoria-street Sewer; is that in a satisfactory state?—No; the outlet of that sewer is in a bad state.

2752. Is that the outlet which has been carried down so far into the Thames?—That is a part of it; there is a wooden outlet, and that is in a great state of decay now.

2753. That is from the wood decaying?—No; but a portion of the sewer close to the river, which we call the outlet, has been built in a sandy soil, and the tide has washed in and out, and injured it very much.

2754. How long has that been made?—About three years.

Mr. *Gurney* stated that Mr. Hawksley was going out of town, and would be glad if the Committee would take his examination.

The *Committee* assented.

Mr. *Thomas Hawksley,* called; Examined by Mr. *Gurney.*

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2755. YOU are a Civil Engineer?—Yes.

2756. Have you had a great deal of experience in engineering works?—I have.

2757. Particularly those relating to the conduct of water?—Yes.

2758. Have you paid much attention of late years to the drainage of London?—I have.

2759. And the mode in which the Thames can be purified?—Partially purified.

2760. You are not of opinion that there is any way by which it can be perfectly purified?—Certainly not.

2761. Have you paid attention to the scheme proposed by the promoters of this Bill?—I have.

2762. Have you been requested on behalf of the Corporation of London to give them an opinion on the subject?—Yes.

2763. Have you gone into the scheme in order to see whether it is one that you could recommend them to support?—I have.

2764. Now will you state what is the cause of the present impurity of the Thames?—The present impurity of the Thames arises partly from the admission of sewage into it, partly from the removal of the old London Bridge, which operated as a weir, and prevented the tidal action being so strong as it is now; partly from the action of steamboats, which prevents the mud depositing out of the water, and therefore always exhibits it in the water—for instance, now there are scarcely any mud banks, whereas formerly, within my memory, there were a great number—partly from the smaller quantity of water that comes down the Thames in dry weather, in consequence of the great increase of agricultural drainage, and the larger quantity of water, which is no small matter, taken out

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of the Thames by the water companies for the supply of the metropolis; and which bears a very considerable proportion now to the whole volume; and partly also from the action of steamers upon the banks of the river below bridge. I have been down the Thames and observed that repeatedly. The wash upon the margins of the river is very destructive to the banks, and is always loading the water with a considerable quantity of soil, and clay, and dirty matter, which discolours the water; that must be distinguished from sewage; it is clean dirt, while the other, the sewage, may be described as foul dirt. Those combined causes operate, I believe, to a much greater extent in producing the discolouration of the water, which is frequently attributed to the admixture of sewage, than the sewage itself; therefore I have no hope that the Thames can be cleansed by the removal of the sewage, although it is undoubtedly desirable to remove it.

2765. The storm-water; have you mentioned that?—The storm-waters also produce a much greater effect than they formerly did, because the storm-waters now bring down the surface refuse of two millions and a half of inhabitants; whereas a century ago there were only 600,000 or 700,000 inhabitants; and of course the storms now influence the Thames so far as this cause of impurity goes to a much greater extent than they formerly did, and will continue to do so after any practical system of interception is adopted.

2766. Of these several causes of the impurity of the Thames, do you see any of them that can be to any extent removed?—None excepting the sewage-water, and that of course when it is not materially intermixed with rain-water, because it is almost impracticable, in point of expense, and also in point of magnitude of channel to remove the sewage when it is largely intermixed with the storm-water.

2767. The tidal action is much more violent than it used to be since old London Bridge was removed?—Very much indeed; in fact the scouring of the river is now so great, that the foundations of other bridges have given way; that is undoubtedly attributable to the removal of the weir; for it was practically a weir that existed at old London Bridge.

2768. In consequence of that, is there a larger amount of dirt always carried backward and forward in suspension in the water of the Thames?—Yes; it is not allowed to deposit.

2769. I think you mentioned that the upland waters are now considerably increased in the time of rain?—They are considerably increased in this way, that as the metropolis, or the district in which the metropolis is situated, becomes more fully paved and roofed, storm-water runs off more rapidly, and also in greater quantities loaded with foul matter; even soot is a material ingredient in the washings of roofs.

2770. The drainage of the district also adds to the rapid flow of the water, does it not?—Yes; that might be intercepted to a considerable extent, especially on the south side, in the manner in which the upland waters are intercepted in Lincolnshire, where for many years past it has been the practice to make a large catch-water drain to receive the upland waters, and never to allow them to come down to the fenland.

2771. *Committee.*] You think a catch-water drain an advantage on the south side of the Thames?—Particularly on the south side; a most important advantage. That is not such a drain as I see indicated upon that map; that is a low level sewer.

2772. At what level should you think such a drain ought to be constructed on the south side of the Thames?—I should think (I am not now referring to the map, which must govern me in a conclusion of that sort), at something like 10 or 15 feet above high-water mark; in fact, the lower the better, providing the buildings do not spread beyond it, to produce a great amount of impurity; it must be of very large area, to act at all times; and should receive only tolerably pure water, otherwise, it must be a covered drain, which would be an immense expense.

2773. You would make it as an open drain?—I would, just as the Car Dyke in Lincolnshire, which proceeds many miles, taking the whole of the upland waters, and conveying them to the sea, independent of the low land waters.

2774. As it would be an open drain, you would not allow any sewage to go into it?—I would not; and if there was any sewage beyond it, I would carry it under it.

2775. The north side of the Thames; should you recommend any intercepting drain there, on the north side, between the high ground and the river?—Certainly;

Certainly; there ought to be several. There should be one, for instance, in Oxford-street and Holborn; there might be another in the New Road; and there might be a third, for those would be comparatively cheap operations, being of smaller size, on or about the line of the Regent's Canal. That is a very excellent guiding contour for that purpose.

2776. Those several intercepting drains would be covered?—Yes, and they would all be of considerable depth; perhaps 20 or 30 feet below the surface; and they would all help the one to free the other, to prevent any excessive volume of water coming into any one receptacle; the construction of several, instead of one, would be much more convenient, and would not affect the metropolis so much.

2777. Would they go under the level of the present sewers that cross there?—Yes, that would be almost a necessary incident in an engineering point of view.

2778. Mr. *Clerk.*] Such sewers would deliver by gravitation above the tidal level?—All except the lower sewer; the lower sewer must be quite independent.

2779. For certain districts a low level would be still necessary?—A low-level sewer is necessary from above Fulham or Hammersmith down through Westminster, and from Westminster through a portion of the city of London, and then through Poplar, and so on to Bow Creek. At Hammersmith a large tract of land, which is built upon, is not more than three feet above high water; the Birdcage Walk in St. James's Park is not more than three feet above high water: and I have seen the water at a high tide, when there has been a conjunction of the sun and moon, and an accelerating wind, bursting through the gratings near the Birdcage Walk.

2780. You have considered this scheme; do you think it would materially cleanse the Thames?—No, not materially; I have given reasons why it would not materially cleanse the Thames, that is to say, it would not prevent the discolouration of the water, but it would remove a considerable amount of feculent matter, and prevent that going into the Thames; the whole of the feculent matter of London amounts to about 10 grains in a gallon of Thames water; the water which enters the Thames as sewage, and the upland water which comes down in dry weather, are together about 10 times the volume of water which is pumped into the metropolis, and, taking them both together, it would make about 1 grain in 7,000 grains; the feculent matter which enters into the Thames is, when mixed with the volume of fresh water coming down the Thames, about 1 grain in 7,000.

2781. Do you consider it important that the Thames should be preserved as much as possible free from sewage?—I think so.

2782. Now, in order to attain that object, do you consider it of importance that the whole of the urban district should be intercepted from the discharge of sewage to the Thames?—Yes; the water of the urban district should be conveyed down below London, and the water of the upland district should be conveyed out at the nearest available place in an engineering point of view.

2783. That upland water being kept free from sewage?—Yes, of course.

2784. If it is not kept free from sewage, you would have the same evil that now exists?—Yes, it would become a little Thames.

2785. Does the present scheme provide sufficiently for the existing sewage from the Thames?—I think not.

2786. You say it does not go high enough up the river?—That it does not I think is very manifest, because the population is becoming very dense in districts several miles above the point at which this sewer terminates.

2787. *Committee.*] Are you speaking of both sides, both the south and the north, or limiting your observations to one side?—I am limiting that particular observation to the north side. At the same time I wish to observe, that I think on the south side the sewer ought to be made of such a depth as will enable it to be extended in a short time as high as Wandsworth. After the construction of Battersea Park, there will be a dense population gathered about that place.

2788. Mr. *Clerk.*] In that respect you think this present scheme is not well devised?—I think it is not well devised with a view to future necessities.

2789. *Committee.*] What increased depth would it involve on the south side?—Perhaps 15 feet. I do not think it is necessary that the sewer should in all parts have a fall of so much as four feet in the mile; it is desirable, but there are certainly other things of greater importance than that amount of fall to be considered.

2790. Lift in pumping at the end?—Yes; but rather more with a view to the

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extension of the sewer into the districts that are likely to become occupied hereafter. The velocity is only affected in proportion to the square root of the fall, so that a diminished fall has not the effect which some persons imagine.

2791. Mr. *Clerk.*] Then the extension of this tunnel to Fulham would not add very materially to the depth at the termination of the reservoir at Bow Creek?—No, I think not

2792. Is the present scheme, in your opinion, sufficient to remove the present sewage of the metropolis, that which it professes to carry off?—Not that which it professes to carry off; it would remove the sewage of the metropolis, which amounts on the north side now in dry weather, when the companies are pumping in the largest volume of water, to about 11,000 feet a minute.

2793. The sewage itself does amount to that at the present time?—Yes; that is about the amount.

2794. How do you arrive at that?—In this way: we know that the companies are delivering into London in dry weather at this time about 60,000,000 gallons per diem. The New River Company, for whom I am acting as consulting engineer, are delivering into their district alone about 20,000,000 gallons per diem, and they serve rather less than one-third of the metropolis; and to that must be added the water from breweries and manufactories, and from springs and wells, and all other sources, the increase of which amounts to from 15 to 20 million gallons besides; so that I think about 75,000,000 gallons may be taken as the summer amount of sewage; of which two-thirds will be the amount on the north side, and one-third on the south side.

2795. When a constant supply shall be substituted for the intermittent, do you expect a great diminution in the quantity of water?—No; I should apprehend for some time there will be a great increase; afterwards that will be diminished by the removal of overflow spouts and other causes of waste, which will be gradually taken away; then it will settle down to between 20 and 25 gallons per head per diem on the yearly average.

2796. What is that compared with what it is now?—I think that now it amounts to somewhere about 22 gallons.

2797. Even when it is settled down, there will be an increased supply, you think, under the constant system?—Yes, I think there will be a great increase in the number of baths, and other appliances of that kind, which require a considerable quantity of water.

2798. Therefore there will be more sewage water to be carried off?—Yes.

2799. Mr. *Clerk.*] You mention that quantity as the supply per diem during the warm weather?—Yes, 60,000,000 gallons daily.

2800. Is that quantity delivered equally throughout the 24 hours?—No; we know, on the system of constant supply, from a great variety of experiments, that the quantity which is delivered in an hour of maximum consumption is from 2 to $2\frac{4}{10}$ times the average quantity during the 24 hours. That usually occurs in the morning; but in some districts, where the houses are large and the dinners are late, it takes place in the afternoon.

2801. Is it in that way that you arrive at the calculation of the discharge per minute from the sewers of the existing sewage?—Yes; of course any system of sewage, to be effective, must take off the maximum volume, and must not be founded on an estimation of the average; that would be delusive.

2802. Do you take 11,000 cubic feet per minute as the maximum discharge at the present time, or under the increased water supply?—At the present time, and estimating the hour of maximum delivery at only double the average of the whole 24 hours.

2803. You take that as the maximum?—Yes.

2804. Then you assume there will hereafter be an increase in consequence of the greater supply of water under the continuous system?—Yes, a slight increase, I do not think it material; but there will be a great increase from the augmentation of the population.

2805. Does this tunnel sufficiently provide for the prospective increase of the population?—No, I think not; it does not appear to me to provide at all for the prospective increase.

2806. We hear its discharging power given at 20,000 cubic feet?—Yes; that is what its discharging power is when it is perfectly clean and unobstructed, and when it is not tailed by the stoppage of the engine, or any other cause.

2807. Then do these 20,000 cubic feet per minute represent rather more than it will be in practice?—Mr. Gibbs stated it at 15,000 cubic feet. I think

Mr.

Mr. Gibbs' statement is an unfavourable statement. It may be fairly taken to yield 18,000 cubic feet.

2808. Then the maximum of the present sewage with the present water supply will be 11,000 cubic feet per minute?—Yes.

2809. Is there a large portion of London with the present population insufficiently drained, and which when sufficiently drained would add a large amount of sewage to such a tunnel?—Yes.

2810. Can you form any idea what that area is?—No, it is not easy to do so. Mr. Bazalgette has made a statement on the subject, which I take to be correct.

2811. Then, as I understand you, this tunnel does not provide sufficiently for sewage alone?—For sewage alone, if it were possible to separate it from rain-waters, I think it provides sufficiently.

2812. For the present time?—Excepting that as regards its engineering features, I think it might be improved; but with regard to delivering capability, I think it is quite sufficient to remove mere sewage; but there are a vast number of days in the year on which mere domestic sewage——

2813. *Committee.*] Are you speaking of the north or south now?—I am speaking particularly of the north now; but there are a vast number of days in the year in which this quantity of sewage is mixed with rain, and it then is decidedly insufficient to take off the intermixed water.

2814. Mr. *Clerk.*] Is it your opinion that any work of this kind should be adapted so as to carry off a considerable, or certain proportion of rain water?—Yes. I think, taking days upon which only a quarter of an inch of rain falls, and estimating that that rain, which is very commonly the case, falls, not as has been assumed, uniformly through the whole 24 hours, but in two, or three, or four hours, that it would be fair to take the volume to be carried off at the 16th of an inch only in an hour, and to apply that calculation to only about 12,800 acres of the whole 47 miles of drainage area on the north of the Thames. If we take these elements which are certainly taken favourably to the promoters of the scheme, it would give you 50,000 cubic feet a minute to be carried off in addition to the sewage water, or rather it would increase the sewage water to 60,000 cubic feet, because the washings of the streets and the washings of the roofs are as foul as the water which runs away from the houses, and would require a sewer of from 15 to 16 feet in diameter.

2815. *Committee.*] That is to say, if it were to be carried off by one intercepting drain?—By one drain on this system.

2816. As I understand, your plan was rather to have several intercepting drains?—Yes; but I am now addressing myself to the scheme as it appears on the wall. Unless some system of that sort is adopted, it is quite delusive to suppose that the Thames will be cleared even of sewage water, because in this climate there are so many days on which a large quantity of rain falls beyond what this sewer is capable of taking off, that practically you would have "80," or perhaps even more than 100 days on which the sewage would be intermixed with the Thames.

2817. Having obtained a water supply from above the tide, why do you still think it of great importance to clear the Thames from sewage water?—I scarcely know how to value the adjective "great:" it is of importance; but it is not of that importance which many persons who have written and spoken on the subject attach to it. Most persons imagine the whole of the dirt in the Thames is sewage dirt; it is nothing of the sort, nor is a tenth, or perhaps a twentieth of it sewage dirt. I mention as an illustration, that the quantity of water which in extreme dry weather comes over Teddington Weir is only about 600,000,000 gallons per diem, and that the town is now being supplied with about 60,000,000 gallons for domestic supply; and if the former quantity were supposed to enter a reservoir which should be of the width of the Thames, and of an average depth of only 10 feet, it would not in one tide occupy more than about a mile in length, and consequently the water flows backward and forward, at that period of the year, advancing towards the sea very little more than a mile in each tide; the observations by floats, which give a somewhat different result, do not give a true result, inasmuch as the floats are put in on the surface of the water and in the middle of the river, where the current is flowing much more rapidly than in other parts of the stream; therefore the advance towards the sea is greater at every tide as represented by floats than it is as represented by the actual volume.

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2818. Mr. *Clerk.*] You have explained to the Committee that the real evil is in the drying of the mud at low-water, the miasma that arises from the Thames?—No. Mr. Bazalgette said something on the subject; I have not made any observation on the subject. Mr. Bazalgette stated that the nuisance which was complained of, and which Mr. Bazalgette admitted to be a real one, arose principally from the discharge of the sewers over the bed of the river when it was unoccupied by the tidal water. It is true; I know that particularly. I also observed the effluvium at the Essex-street Sewer, which has been spoken of; and it is sometimes apparent at the Westminster-bridge Sewer. There was an opening from the Westminster-bridge Sewer, which was very foul, and at several other places. The Fleet is another place where it has been perceptible at times.

2819. I do not understand your recommending a tunnel of 15 feet diameter?—I would not recommend a tunnel of 15 feet diameter unless I was driven to the system which is proposed by the Bill. I would make several intercepting sewers, because the total cost would be less, I believe, and the efficiency greater, than would be the cost and the efficiency of one main sewer; and then the cost of pumping, which is a very serious thing indeed, for the removal of this matter would be amazingly diminished. I may mention that to remove, by pumping, the water of one-sixteenth of an inch of rain, mixed with the sewer water, would require 5,000 or 6,000-horse power merely to keep the sewage flowing.

2820. Of its present capacity?—Yes; and, therefore, the advantage of bringing water down by intercepting sewers from the higher level is perfectly obvious; because, to get those numerous engines into motion, and to get up the steam of that extensive amount of machinery whenever a storm occurs, which sometimes occurs in a very short time, and to keep it in action, and have men on the spot ready for the working of it, and so on, would be a very serious item indeed, and very unnecessary.

2821. It would require a very rapid amount of change in the amount of horse power used for pumping, supposing a heavy storm to come and fill the tunnel?—Yes, and that will fluctuate every hour of the day and night, according to the mode in which the water is being used in London, as delivered by the water companies, and the varying incidents of rain.

2822. *Committee.*] It would require some little time to get to the outfall?—I think, speaking without reference to notes, the velocity is about three miles an hour.

2823. But it would be delivering into the tunnel?—But inasmuch as the sewers are delivering upon the whole length of the tunnel, it would be instantaneous. The tunnel is something like a flute, with holes all the way along it.

2824. Mr. *Clerk.*] I believe you have considered the mode in which it is proposed to construct this tunnel altogether?—Yes, I have.

2825. But with respect to the south side, are the same objections with respect to the north side applicable to the south side?—They apply to a greater extent to the south side than they do to the north, because the south side is particularly flat; therefore it is necessary there to make more ample provision for storm-water than it is on the north side. On the north side the storm-water will, at all events, get into the Thames; but on the south side it will not get into the Thames by gravitation, supposing the sewer choked.

2826. Do you consider that on the south side the point of discharge is low enough down the river at Deptford Creek; supposing the sewage to be discharged in a foul state, and the commercial speculation not to succeed, is that point too near London?—I think so; if it is discharged in a clear state, it is no matter where it is; but if by any mischance the water should not be clarified, by night and by day, and on Sunday, indeed at all times, of course, the foul water, or a proportion of it, must go into the Thames.

2827. I think it was calculated by Professor Miller, that one-seventh of the original matter remained in the water after the process?—Yes; I heard Professor Miller say so. That would be about a grain and a half in a gallon—not a very serious thing.

2828. Do you think that such a work as this could be constructed without a good deal of disturbance to buildings?—No, I think not; it would have to be very perfect; indeed, it would have to be a work of almost impossible perfection if none of the buildings were disturbed in the course of the construction of an underground work like this. In making the tunnel at Liverpool, which passes, after it leaves the sandstone rock, a considerable distance through clay of great firmness

firmness and great thickness, the houses gave way to a very considerable extent; and the same theory was held out previously to the making of that tunnel that is now held out, namely, that no such effect would be produced; yet it is within my own knowledge it was produced, and that a very large compensation has had to be made.

2829. *Committee.*] That was a railway tunnel, and not a 10-foot tunnel, as in this case?—That is quite true; that was a tunnel of more than double the diameter, but the difference of size will not entirely prevent that effect being produced, because the vacuities which are left are no larger in the one tunnel than the other.

2830. You think the difference of size would not prevent the effect of disturbance to the buildings?—I do not mean to say everywhere; but that these things will happen in the course of the operation I am perfectly satisfied.

2831. According to your plan, there was to be several intercepting drains on the north side of the metropolis; we should have much greater alarm in the streets; they would all be moving?—Not so; because it would be possible to carry these smaller intercepting tunnels down the wide streets, down the New Road, and down Holborn. I do not mean to say accidents will never happen; we know that at the Victoria Sewer several accidents of that kind did occur; but they will be much less likely to occur than in a case of this kind.

2832. Your tunnels will be nearer the surface?—Undoubtedly; therefore, the nearer the surface, the less likely to damage the houses, because the motion of the material over the tunnel is at an angle which does not extend to the houses. We find that in coal-fields, which is the very best example of settlement you can have, you break through the strata above, which is frequently clay, wider as the coal is deeper, but with an effect which becomes less serious as the coal is deeper.

2833. Mr. *Clerk.*] Is this scheme of converting sewage into a valuable product in your opinion not sufficiently advanced to be tried as an experiment on so large a scale?—I think it is not sufficiently advanced; I believe it will one day or other become a very valuable commodity; but I think enough is not known at present on the subject to warrant an experiment on two millions and-a-half of people; in twelve months from the present time, I believe everything that is material will be known on the subject from the experiments which Mr. Wicksteed is making at Leicester.

2834. *Committee.*] When you say everything will be known in a year's time, you mean everything respecting Mr. Wicksteed's experiment?—Mr. Wicksteed's experiments and Mr. Higgs' are identical.

2885. You mean everything relating to that experiment?—Yes.

2836. It may be possible, that although that mode of applying the refuse usefully hereafter may not succeed, some other mode may?—No doubt; I think it is much more likely that solid manure will be found to succeed than the liquid; I think the liquid is quite an impracticability. I had occasion some time ago to make a calculation on the subject, and I found it would require a diameter of 36 miles about London to take up the sewage water.

2837. Mr. *Clerk.*] Unless there is a large area close to where the liquid sewage is discharged, it is of no value?—It is not.

2838. Is the commercial value of the solid manure as yet ascertained?—No.

2839. Mr. Wicksteed is carrying on the experiment on a large scale at Leicester?—It is on a very small scale at present; but it is going to be upon a scale, as compared with the metropolis, of 60,000 to two millions and a half.

2840. Are you aware whether at Leicester Mr. Wicksteed, who is experimenting on the sewage, guarantees the corporation?—I believe that is the case; a company is formed to which Mr. Wicksteed is the engineer, for the purpose of developing the value of this sewage. Mr. Wicksteed makes, at the expense of the company, an outfall sewer, and erects the works, and I believe he guarantees the corporation against any loss, and also agrees to transfer the works to the corporation on certain terms, in a certain number of years, if so required; but the whole risk is that of the company, and they guarantee the corporation, instead of the corporation guaranteeing them.

2841. Have you considered the proposed plan for reservoirs at the terminus of the tunnel?—Yes; which reservoirs are you speaking of; the larger ones, or the smaller ones.

2842. Those mentioned by Mr. Gibbs on the second day?—Yes.

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2843. The reservoir consisting of 24 departments, covering one acre?—I should say, for many reasons, that is totally inadequate.

2844. Considering the length of the process as detailed before the Committee, would it require a very extensive area for reservoirs?—It would; I believe, it is now ascertained pretty well that the deposition takes place, or rather precipitation takes place, in about four hours; it has been exhibited here in a much shorter time, but that was only precipitation through a short space.

2845. Do you know whether that is the time which is occupied at Leicester, or about the time?—No, I do not know it of myself; but I have heard so.

2846. As I understand, the conclusion you have arrived at is, that this scheme will not effect any great benefit to the metropolis, even although it might carry down a certain amount of the regular part of the sewage for the use of the company?—It would be beneficial as a low-level sewer in combination with other sewers, and if altered in its engineering features so as to admit of extension to Hammersmith on one side, or to Wandsworth on the other, the scheme would be materially improved.

Cross-examined by Mr. *Hodges.*

2847. I understand you to say it would be beneficial as a low-level sewer?—Yes.

2848. You have had a great deal of experience in matters of this kind; would you anticipate any difficulty in carrying out the proposed tunnel?—No; there is no engineering difficulty; if you find money enough, I am quite sure the engineers will find skill enough.

2849. You concur with what Mr. Brassy told us, that he would undertake to do it without any fear of meeting with engineering difficulties?—We never know what engineering difficulties are. Suppose you meet with sand or gravel full of water; one person would be inclined to describe that as an engineering difficulty; I should not; but no doubt it would cost a great deal of money to get through.

2850. *Committee.*] Your shareholders might?—Yes; it would be a pecuniary difficulty.

2851. Mr. *Hodges.*] Do I understand that your objection to this scheme arises in part in consequence of the value of the manure not being ascertained?—It is an objection to the grounds upon which this scheme is put forth.

2852. That is one of the grounds you have for objecting to the scheme?—To the scheme of the company, because I think it might leave the Commissioners as tax collectors of 30,000*l.* a year for the benefit of the company.

2853. Now, you have heard that they spend 200,000*l.* a year in drainage?—I am not aware of that.

2854. It was stated just now by the last witness, that their annual expenditure was 200,000*l.* a year?—I did not observe it.

2855. The annual income?—Part of it may be spent in interest on borrowed money, and various other things; and officers and management.

2856. Does it not seem a small amount to appropriate 25,000*l.* to a tunnel which you admit is a beneficial thing, though as a low sewer?—No; I do not think it is a very proper way of carrying out a work of private enterprise. Private enterprise pre-supposes that the capitalists take the risk in anticipation of considerable profits; this is not a work of private enterprise at all; it is a work which proposes to give to the contractors a rate of interest which is commensurate with interest paid on money invested in the funds, and to do this upon the security of all London, which is just as good as the security for money invested in the funds, and then to give them the advantage of getting whatever they can out of their manufacture besides.

2857. You think it would be proper not to do it on that account?—I think if the company have such very good prospects, they ought to make the work at their own expense, and it should not be a charge on the Commissioners.

2858. How long would you propose that Parliament should wait for the purpose of ascertaining the value of this sewage before they grant powers to some person to make this work?—I cannot offer any opinion on what Parliament ought to do. Parliament will take into consideration the means of the rate-payers, and the different interests involved, and the varying amount of the benefits to be conferred on different districts; my own opinion is, that the completion of the drainage of London ought to be carried out as rapidly as Parliament, having regard

to

to those circumstances, shall think fit. As an engineer, I think the sooner the better; as a political economist, I cannot give an opinion.

2859. You seem to have paid great attention to the state of the river; do you not think that the river is likely to become worse rather than better?—Yes.

2860. The water supply, taken high up the river, will be greatly increased?—Yes; more water will be abstracted from the river, and more filth will come into it.

2861. Now, you have said that you considered that the daily extent of the adulteration of the water was as 1 grain in 7,000 grains?—Yes.

2862. That is a thing of daily occurrence, is it?—Yes, it is constantly going on in dry weather; at other periods in the year, of course, the adulteration is not so great; but we ought to take the worst period of the year in considerations of this kind.

2863. Although it is that small quantity, looking at it as a daily quantity, if that quantity continues to flow backward and forward with the flux and reflux of the tide, it accumulates every day?—No; that is a mistake, because the quantity of water I have calculated on is always coming over Teddington Weir, so that it is preserved in the same state of admixture; I have taken the maximum state of impurity.

2864. You do not quite understand what I mean; do you suppose that the sewage-water is carried out to sea by every tide?—No.

2865. You know it is not?—Certainly.

2866. It is detained in the river?—Yes.

2867. Surely, if the adulteration is daily what you have stated, and it is not carried out to sea, it must increase?—No, because there is always just that quantity of water coming in at one end which dilutes the sewage as it flows into the Thames, to the extent I have stated; if not, you have only to carry your supposition on a little further, and you will find the river will become solid.

2868. I want to ask you a question with respect to your calculation as to the amount of sewage-water and rain-water that would fall; I understand you base your calculations on the same data as those of the last witness, which include those very remote districts of Hammersmith, Mortlake, and so forth?—No, I have not.

2869. Have you not taken the whole area?—No.

2870. Where did you confine your water-fall to?—I took a district commencing at Bow Creek, and extending up to Hammersmith; Bow Creek at one end and Hammersmith at the other; then I took it from the Thames northwards, as far as the ground is covered by a dense population.

2871. How many acres?—12,800 acres, out of 47 miles.

2872. You calculate on 12,800 acres?—Yes, only.

2873. You did not use the same means of arriving at the same result as the last witness?—I did not, nor have I been in communication with the last witness on this subject.

2874. The time when the greatest quantity of water is delivered by the water companies is in the summer-time?—Yes.

2875. If any storms happen at that time, the evaporation is much greater at that period of the year than at any other time?—Yes; but the maximum evaporation from a reservoir constantly exposed to solar heat, never exceeds an eighth of an inch in 24 hours in the hottest weather.

2876. When you get the maximum of water supply, you get the minimum fall of rain?—No.

2877. Does not less rain fall in the summer than in the winter?—No; for instance the month of July, commonly taken to be a very dry month, because it is a very hot month, is one of the wettest months in the year.

2878. Is not evaporation quicker in summer than in winter?—Certainly.

2879. The quantity of rain falling in the summer is, in your judgment, as great as in the winter?—I do not say that; but I say that in particular months in the summer it is greater than you almost ever meet with in winter; for instance, the rain falling in London averages about 23 inches annually; that is something less, if you distribute it over the whole 12 months, than 2 inches per month; and yet I have known in London 2 inches to fall in one hour; it did so in August 1846; and by Mr. Dollond's observation at Camberwell, there were 3 inches and 3-10ths of rain falling in 2 hours and 20 minutes; over a portion of that time the rain fell at a rate exceeding 2 inches in the hour.

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2880. You would not recommend the formation of a tunnel to carry off all the storm-water?—No; I have limited the quantity of rain to be intercepted to 1-16th of an inch in an hour.

Re-examined by Mr. *Clerk.*

2881. I wish to ask you whether you have heard that the Metropolitan Commissioners of Sewers were expending 200,000 *l.* in drainage; whatever the expenditure may be, I apprehend that the public get the immediate advantage of that in improved drainage?—Yes.

2882. That is, in the construction of sewers?—Excepting that there are expenses of management, collection, and various other things, which are a deduction, and also the interest to be paid on money borrowed.

2883. Can you see any corresponding benefit to the inhabitants of London for the tax which is proposed to be put upon them to supply this guarantee to the company?—No; I think this ought either to be truly a private enterprise without risk to the public, or it ought to be done by the public without advantage to private capitalists; it should be one way or the other.

Examined by the *Committee.*

2884. If done by the public, as you call it, it must be done at the cost of the inhabitants of London, or the nation at large?—Unquestionably it ought to be done by the inhabitants of London, and then it would be done on their own responsibility, and they would exercise their judgment as to how to do it, and in what portions.

2885. You were understood to state that you thought that the depth of the tunnel on the south side was not the best that might be adopted; having regard to the future exigencies on that side of the river, you would be deeper than that?—I would be deeper on both sides.

2886. Would you object to it on the north side also?—It is a curious fact, that the very lowest land that you have to drain on the north side is the land most remote from Bow Creek, a very extensive area, becoming very rapidly populated; that is, between Hammersmith and Fulham.

2887. And you would have your sewer below the Victoria Tunnel, instead of being on a level with it?—I would; I only consider that an alteration in the engineering features of the scheme, and one that is perfectly practicable. Although I differ from the scheme, I do not oppose that as a formidable objection, because so far the scheme might be corrected.

2888. Do I understand you to say, that you thought the scheme as proposed might be advantageously combined with your own system of smaller and more numerous sewers on a higher level?—Undoubtedly, together with those corrections which I have mentioned.

2889. Assuming no powers were conferred on this company, which would give them a right to object to any other system being engrafted on theirs, are there no physical features in this scheme which would preclude their being so combined?—Certainly not; there is an economical consideration with respect to the guarantee, which I give no opinion upon.

2890. I did not quite collect from you, what your view is as to the expediency of intercepting, taking the expense into consideration, and the demand for the application of money in improving the general system of sewers in London; are you or are you not an advocate for intercepting the sewage water of London by tunnels?—An advocate for it; a decided advocate for it; I think this: that where you have so immense a population congregated in so small an area, you ought to do everything you possibly can to secure the sanitary condition of that population.

2891. And therefore, having regard to the necessity which exists for a large expenditure of money in improving the system of sewage, and the expense of intercepting the sewage before it enters the Thames, you are an advocate for incurring both those, and incurring them at once?—I am.

2892. Mr. *Clerk.*] Would you require that that system should be constructed at lower levels, so as to drain those districts which are at present unaccommodated?—I did so state it; I think that is essential, for the reason I gave, that the remote parts are on the lowest level.

2893. *Committee.*] Do you consider it advisable, in the first instance, to construct the sewers that are to be made on a high level, or in the first instance to commence with the sewers on the lowest level?—I would rather commence with the high

high level, because it would combine with the new drainage more efficiently at the highest parts of town; the highest and the lowest levels are the worst drained. The highest portions are extending; the new drainage is there being wanted every day. I would make one of those intercepting or catch-water sewers at the high level, and make all that right as I went on; I should have nothing to do there afterwards. I would not continue to do wrong on new ground with the view of doing something else afterwards to set me right. Mr. *T. Hawksley.* 10 June 1853.

2894. Mr. *Calvert.*] Does that remark apply to the south-side as well as to the north?—It applies in a degree to both sides of the river.

Mr. *Bazalgette* re-called.

2895. *Committee.*] Do you wish to correct any error in the statement that you have made?—I stated, that my impression was, that about seven miles of new sewer were constructed in the last year on the average; I find that there were about 14 miles constructed in 1852.

2896. Entire new sewers, or were there repairs to other sewers in those 14 miles?—No; I mean entirely new works.

[Adjourned to Monday next, at half-past Twelve o'clock.

Lunæ, 13° *die Junii*, 1853.

LORD SEYMOUR IN THE CHAIR.

Mr. *William Haywood*, called in; Examined by Mr. *Gurney.*

2897. ARE you Engineer to the Commissioners of Sewers for the city of London?—I am. Mr. *W. Haywood*

2898. How long have you been so?—Seven years.

2899. Previous to that, you were assistant?—I was.

2900. Have you had, therefore, considerable experience in sewage works?—Nearly the whole of my time for the last seven years has been devoted to sewerage works.

2901. Have you had the subject of the intercepting of the sewage from the Thames, so as to prevent it going into the Thames, brought under your consideration?—Yes.

2902. Have you considered the scheme of the London Drainage Company?—I have.

2903. Have you made a report on that in connexion with Mr. Bazalgette?—I did.

2904. Which is before the Committee?—Yes.

2905. Now, in your opinion, is it well devised for the purpose which it professes to have in view?—It is not.

2906. State your objections to it?—The scheme, in my opinion, is not sufficiently comprehensive to fulfil the principal purpose which the Commissioners of Sewers have in view in carrying out such a scheme, namely, the uniform interception of the sewage from the Thames within certain limits.

2907. What limits do you think ought to be taken if the object is to purify the river?—I think that sewers should be provided capable of receiving all the sewage that is likely to accrue until the population of the metropolis is doubled, and also a certain portion of the rain-fall, which falls upon the surface indicated upon the plan before me, which on the northern side is about 44½ square miles, and upon the southern side about 21½ square miles.

2908. *Committee.*] Until the population is doubled?—Yes; I have expressed that in the report.

2909. Mr. *R. Gurney.*] Mr. Mitchell stated that; you heard his evidence?—I think he said so.

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2910. Which he said he thought would be in the next 30 or 40 years?—Yes.

2911. Are you able to form any calculation of what is the amount of sewage which now comes into the Thames?—It is stated in the report; it is taken at about 9,100,000 cubic feet on the northern side per diem.

2912. Mr. *Calvert.*] Be kind enough to give us the page?—Page 14, and on the southern side at 3,000,000 cubic feet per diem.

2913. Mr. *Gurney.*] Does that flow equally throughout the day?—Very unequally indeed.

2914. Are you able to state in what number of hours one-half of it flows?—I have assumed that one-half of the total daily quantity of sewage is delivered at and falls into the river during six hours of the day.

2915. You have accounts showing the times at which it does flow?—That opinion has been formed from, and is the result of my own experience for the last seven years, and after consultation with the officers whose special duty it is to look into such matters, and to a very great extent by personal observation made in the sewers. It is impossible to state the total quantity running at any one minute, for there are probably never two minutes in which the quantity of sewage coming down from any one sewer is the same. Throughout the night there is a very small quantity; about six in the morning the first increase of sewage takes place; it continues increasing until about eight o'clock, and then rapidly increases till about twelve o'clock, which I think may be said to be the period of the greatest flow; it then decreases until about two o'clock. Between the hours of eight in the morning and two in the afternoon, I consider that one-half of the daily quantity of sewage delivered into the Thames is discharged, the other half being delivered in the remaining 18 hours.

2916. During those six hours, as I understand you, it does not flow uniformly?—The sewage does not flow uniformly at any period of the day. There is a wave of sewage.

2917. Supposing it to flow uniformly during these six hours, what would be the quantity per minute?—On the northern side 12,638 cubic feet per minute.

2918. As it does not flow uniformly, of course during some portion of that time there would be a large flow?—During some portion of those six hours the flow will probably exceed 12,638 cubic feet per minute; during some portion of the six hours it may be slightly less.

2919. Then the delivering power of the proposed tunnel would not be sufficient to take double the present maximum quantity?—The 10-feet diameter intercepting sewer on the northern side of the river would not take double the present quantity of sewage during those six hours.

2920. Now, is it possible to take it, in your opinion, without some intermixture of rain, if the sewage itself is to be carried off?—Quite impossible if it is intended to free the Thames, to any extent, from its present state of pollution.

2921. I suppose you think it would be impossible to have works so constructed as to carry off all the rain-fall in times of storms?—It is not impossible to do it. But of course the expense would put it entirely out of the question, the construction of works of such magnitude.

2922. What number of days do you think it would be fair to exclude altogether, when the fall is the greatest in the year?—I think the sewers should be of such sizes that there should not be above 20 or 30 days in the year in which the sewage, in any considerable quantity, should go into the Thames.

2923. Is that about the number of days, upon the average, when the rain exceeds one quarter of an inch?—The average of the last four years gives 29 days in the year in which more than a quarter of an inch of rain falls in 24 hours.

2924. Do you think that the tunnel should be so constructed as to carry off the rain-fall on days when it is less than a quarter of an inch?—The largest portion of the rain-fall on those days.

2925. Such portion as would first flow with the sewage?—Yes, such portion as would be the filthiest in its nature.

2926. Is that the clearance produced by the beginning of the rain-fall; is that as polluting as almost any part of the sewage?—It is a different species of pollution; but it must necessarily pollute very much when you consider the enormous traffic of the metropolis, that there are probably from 25,000 to 30,000 houses, the greatest portion of whose existence is passed on the thoroughfares of the metropolis, it is obvious that whenever a rain-fall occurs, that a very large quantity

of

of the horse deposit is washed into the sewers. In fact, the sewage after the first scour of rain is dirtier, and apparently filthier, than the ordinary flow of the sewage.

2927. Then there is all the decomposed vegetable matter?—There are the usual washings of the surface of a huge population; all of which goes into the sewers with the first rain, and is quite as filthy as the ordinary flow of the sewage.

2928. At what rate will a fall of rain of a quarter of an inch, in your judgment, be carried into the tunnel?—In a very large portion of the metropolis some of it would go there almost immediately, from the paved surfaces of the metropolis, *i. e.* the dirtiest surfaces, within 10 minutes after a fall of rain of any extent, a portion of that would flow into the sewers, the filthy water from the paved surface would continue to flow into the sewers so long as rain continued, and would continue dirty because there is the continual addition of dirtiness to the surface of the streets so long as the traffic is continued.

2929. You heard the evidence of Mr. Gibbs, did you not?—I did.

2930. He stated in his plan that he produced, he pointed out one of the districts consisting of 3,450 acres, which he said would discharge the rain in four hours?—I think he did.

2931. Can you tell me what would be the discharge per minute, even taking that one district alone, 3,450 acres, and supposing a quarter of an inch of rain discharged in four hours?—I cannot tell; how many acres did you say?

2932. Three thousand four hundred and fifty; here they calculate 13,045 cubic feet per minute?—It would be something like that.

2933. That to be discharged in four hours?—This is about correct; about 13,000 cubic feet per minute.

2934. That would be taking only one of the discricts, which he said would discharge their contents into this tunnel?—It would be about that quantity.

2935. Have you directed your attention to the provision at the end of the tunnel for delivering the sewage, or delivering rather the contents of the tunnel?—Do you mean the pumping power?

2936. Yes?—I have.

2937. Supposing that was to deliver at the rate of 20,000 cubic feet per minute, which you say is the full delivering power, supposing there were no obstacles?—I did not say so, but it is so.

2938. We are both agreed on that; what horse power would then be required to empty that?—I have not the memorandum by me; but I think about 2,000 horse power to lift it.

2939. What lift do you calculate for?—Fifty-eight feet.

2940. I believe you have considered the scheme on the south side, as well as on the north?—I have considered the whole scheme of the company.

2941. Have you any objections to take to the scheme on the south side; I did not propose to go at length into that, because the City Commissioners are almost entirely confined to that, except for the borough of Southwark?—No; I have no objection to go into the question of the south side.

2942. Does it appear to be objectionable, is what I meant?—It seems to have the same defect as that on the northern side; it is not sufficiently comprehensive in its nature.

2943. Do you think that the degree to which the Thames would be purified by this scheme, would be at all compensation for the expense which would be incurred?—I can scarcely answer that question; because the injuriousness of the present state of the Thames to the metropolis has been decided upon by medical men, who state that it is absolutely essential for the health of the population. If I may be permitted to differ from medical men at all on such a point, I should say it is desirable to do it, but that the effects have been excessively exaggerated.

2944. Have you paid attention to all the evidence and opinions that have been given upon this subject?—I have.

2945. Have you traced at all the course of the cholera in those districts?—I have read about it; I have not traced it.

2946. But having attended to that, do you think it very much exaggerated, the effect of the sewage passing into the Thames?—Exceedingly so; there cannot be a doubt about it.

2947. Did you pay attention to the evidence of Mr. Hawkesley as to the quantity of matter that remained in the Thames?—I did.

2948. Did you agree with that opinion he gave?—I did.

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2949. Now is there a large quantity of ballast that would pass into the tunnel?—There is a very large quantity.

2950. Are you able to form any estimate of what would be the amount that would pass?—I can only say it must be estimated by thousands of cubic yards annually, the quantity of road drift that gets into sewers is perfectly surprising.

2951. *Committee.*] In the shape of sand, or much larger material?—Sand and gravel.

2952. Wear and tear of the roads?—It is principally from the macadamised roads; but it is surprising also to find the quantity of gravel and sand which gets into sewers which run beneath roads having a paved surface, a granite surface; but from the macadamised roads in times of heavy rains there are vast quantities of ballast go down into the sewers.

2953. Does that impede the operation of the sewers at present?—Yes, considerably; if the sewers have not sufficient water or sufficient velocity of current in them to remove it, it deposits, and forms a concrete, and it is utterly impossible to remove it without the help of a pickaxe.

2954. Have you, during the seven years you have been at the head of the sewage management of the city of London, ever had occasion to use, or order to be used, a pickaxe for the purpose of cleaning the sewers?—I have not had occasion to order it, but I am aware that it is done perpetually.

2955. Do you find the sediment is greater in the larger sewers than in the smaller ones?—In the larger sewers there is less than in the smaller ones, because in the larger sewers there is mostly a current, with a sufficient velocity to remove it, but in the smaller sewers it deposits and concretes.

2956. That is, supposing there is not a sufficient flushing of the small sewers?—Supposing there is not a sufficient velocity in the current to remove it.

2957. A smaller sewer requires a smaller quantity of water to flush it?—It is possible to obtain a velocity in small sewers as great as that in large sewers, by making the sewers of a proper shape. But in the small or collateral sewers it is impossible to obtain that; where the sewers are only 400, or 500, or 600 feet long, and there is but little water in them, it is impossible to obtain the velocity in them sufficient to remove inorganic substances, if they get into them.

2958. Is that inconvenience, resulting from the drift into the sewers, a main objection, in your opinion, to the scheme proposed in this Bill?—It will be objectionable, inasmuch as if it gets into these sewers, and is carried all the way down to Barking, they will have to raise it all up again.

2959. Have you pointed out this in your report?—No.

2960. Then this, which is one very main objection to the scheme, you, having to report on the scheme, have not noticed?—I have not noticed it in the report.

2961. Are the sewers of which you have been speaking sewers with circular inverts?—Yes.

2962. You talk of the Fleet; the Fleet is not a circular invert?—The Fleet has inverts of every possible shape; it varies at every hundred yards of its length in the older portions.

2963. Is that circular in some places?—Yes.

2964. And not in others?—Yes.

2965. Do you not find sediment more where it is not circular than where it is?—The circular form is the best form which can be adopted with large sewers, having large quantities of water running through them.

2966. Is it not so, that in circular sewers you find less collection of sediment than you do in the others?—It entirely depends upon the quantity of water running on that circle, it therefore in a degree depends on the radius of the circle.

2967. Mr. *Gurney.*] But, taking them both the same size, supposing they are all the same in other respects, is there less deposit in the circular than in the other?—The circular is preferable, and less deposit.

2968. *Committee.*] Because a smaller quantity of water produces the rush in the circular, and in the square it requires a larger quantity?—Precisely.

2969. Mr. *Gurney.*] Judging from your experience of the sewers that have been under your care, are you of opinion that repairs would be necessary in this tunnel frequently, or not?—No; I do not anticipate frequent repairs in the tunnel, not for a great many years to come; but of course repairs will ultimately be required in the invert.

2970. Could that be done without closing the tunnel against the ingress of the sewage?

sewage?—Whenever repairs are needed, it will be necessary to shut off the sewage above the point at which the repairs are required.

2971. *Committee.*] How is it done now in any repairs of a sewer at this moment?—In large sewers it is done almost exclusively at night, and by diverting the water at the upper levels into other sewers. In the sewers of the metropolis there are mostly means of diverting and turning the water at the upper portions into other main lines. Of course that can only be done to a certain extent, but it is done to the extent that is practicable. By that means the quantity of water is reduced; and, availing ourselves of the period of the minimum flow, which is at night, the repairs are made. But in very large sewers it is an operation of extreme difficulty, because the storm-waters may come down in a very short space of time; and as a storm cannot be foreseen, the men are obliged to escape from the sewers as rapidly as they can, and proceed with the operation when the storm waters have passed off.

2972. Mr. *Gurney.*] It was stated by Mr. Gibbs, as his opinion, that the more complete the drainage of the country became, the more regulated would be the flow of water from it; do you concur in that opinion?—Certainly not.

2973. What has been your experience where districts have been better drained than before; do you find that the flow is more uniform, or does it come at intervals?—The more you harden the surface of the ground, the more you extend the sewers beneath its surface; and the greater means that you afford for draining the surface quickly and efficiently, the more rapidly is the water delivered, in times of rain, into those sewers. At this present time the whole of the metropolitan outfalls are getting more and more gorged in times of rain, entirely through that cause.

2974. As the drainage has been improved?—Yes.

2975. *Committee.*] What length of sewers are there under the City Commissioners of Sewers?—There are 50 miles.

2976. You have spoken as to the north of the Thames, that any good scheme of intercepting drains should provide for 44 square miles to the north of the Thames?—I have.

2977. Would you state how many of those 44 square miles are under the City Commissioners of Sewers?—One square mile.

2978. Only one square mile?—There is one square mile; only within that square mile there are 50 miles of sewers.

2979. Can you tell me, is that system of sewerage for that one square mile complete?—The sewers within the city are in length completed; but the City Commissioners of Sewers have to improve a large portion of the existing sewers. Those sewers having been built at a time when house drainage, in the modern acceptation of the term, was a statutable offence, and were intended simply to carry off the surface waters. Those sewers are not adequate to the present requirements of the population, and those will have to be remodelled and improved.

2980. But then no new sewers, as I understand, are required, but merely the improvement of existing sewers?—It is possible that there may be a few sewers still required, but very few indeed; it is difficult to ascertain in a city so ancient as the city of London the precise necessities of many of the houses; many are reported to be drained, and after a short time, we discover they are not drained; thereupon it is necessary to extend the sewer up to places where those houses hitherto expected to be drained are found to be undrained, but they are exceedingly few in number. Throughout the whole of the streets there are already sewers; my remarks therefore only apply to courts and alleys.

2981. With respect to the quantity of sewage that is now brought from this square mile into the Thames, we may expect that quantity of sewage will not be increased?—The quantity of sewage will be increased by the addition of the drainage of those houses that are not yet drained into the sewers.

2982. Are there many houses within that square mile that are not drained into the sewers, do you think?—I should not think one-tenth are undrained, and the Commissioners of Sewers have so far completed their system of sewers, that they have been able to reduce their rate.

2983. Speaking of the rate, state what rate the City Commissioners are entitled to raise?—The City Commissioners are entitled to raise 4 *d.* in the pound.

2984. Over what district?—Over the square mile that I have stated.

2985. That square mile is all to the north of the river?—Entirely.

2986. Have they any jurisdiction to the south of the river?—None whatever.

 2987. Have

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2987. Have you, during the last seven years in which you have superintended sewers for the City Commissioners, made any report, having for its object to improve the condition of the Thames?—I have made no report upon that to the City Commissioners of Sewers; but I have well considered the matter; from my position, I have done so necessarily.

2988. Then the Committee are to understand that the City Commissioners of Sewers have not, during the last seven years, given you any direction to make any report for that purpose?—The City Commissioners of Sewers associated me with Mr. Frank Forster, the engineer to the Metropolitan Commissioners, about three years ago, in the consideration of a scheme for the interception of the sewage from the northern districts of the Thames.

2989. Did you agree with the report made by Mr. Frank Forster on that subject; did you sign the report first of all?—No; because I simply went into the question of that portion in which the city was principally concerned; but I necessarily, and for my own information, went into the general consideration of the whole district north of the Thames. I did not sign the report; but I concurred in such portions of the scheme as the city of London was interested in, and, I may also add, gave my general concurrence in the whole principles of that scheme.

2990. Three years ago you were of opinion that an intercepting sewer was desirable?—Certainly.

2991. Are you still of that opinion?—Certainly; looking not only to the present state of the Thames, but to the future inevitable state of the Thames, provided an interception scheme is not carried out.

2992. Then, although you state that you consider the injurious effect arising from the polluted state of the Thames to be exaggerated, yet the Committee are to understand that you still think there are such objections to its polluted state that it is desirable to intercept the sewage, if possible?—Clearly. I think it is proper that this metropolis should free the river as much as practicable from its present condition, having special reference to the future increase of the metropolis in giving that opinion.

2993. Now, considering the square mile which you superintend, do you think that, for the purpose of intercepting that amount of sewage, one drain will be sufficient, or that there should be more than one drain crossing that district as an intercepting drain?—In answering that question, I must say that it is scarcely possible not to take into consideration the general area of the northern side of the metropolis in any scheme of interception; but certainly one drain or sewer would be sufficient for the purpose of the city of London; that is answering that question abstractedly, and with reference to the city alone.

2994. Do your sewers not take any portion beyond that mile of which you have spoken; are other districts drained into the same large sewer?—Yes; the largest portion of the upland district which contributes to the Fleet; the Fleet Sewer only takes a small portion of the city area. In all the outfalls the city of London have provided from time to time for the sewerage of the metropolis: they have held in view the necessities of the upper districts; which have invariably been laid out more or less in conjunction with the officers of those districts, and in reference to the necessities of those districts.

2995. Are many of those districts in which a great part of the sewage remains to be added?—In the metropolis generally there is a vast amount of district sewers needed.

2996. Are there not many district sewers needed in those districts which will be drained into the great sewers of the city, the Fleet?—Certainly. I apprehend that remark will apply to every main sewer there, or taking the area naturally draining into the whole main sewers of the metropolis; I think there is scarcely one of which it may not be said there are sewers needed to be constructed which must ultimately drain into those main sewers.

2997. Are you not, therefore, on that account continually in communication with the Metropolitan Commissioners of Sewers with reference to these drains which open into your sewers?—That is very rarely necessary, because the arterial lines are already defined; their depth is determined; and as they have an existing line and an existing depth already within their jurisdiction, all they have to do is to drain into those depths whenever it is requisite; whenever the engineers of the joint Commissioners think it necessary to co-operate, they do so.

2998. Have they power to open drains into your sewers without any communication with you?—They have power to open drains into the upper portion of the

sewers

sewers which drain through the city; those portions which are beyond the city's jurisdiction, if they require drains into the sewers immediately within the territory of the City Commissioners, they then make application. That application, I need scarcely add, is invariably attended to in the shortest possible time. In the event of there being disagreement, which is a most unlikely thing, for it never did occur even before the necessities of co-operation were so much felt as in the present day, if such contingency should occur, there is a provision in the Act of Parliament for arranging such matters.

2999. You have spoken of the district over which they are entitled by their Act to raise 4 *d.* in the pound; can you say what is the produce of 4 *d.* in the pound in that district?—In round numbers, a shilling in the pound will produce 50,000 *l.* a year; the rated value of the city property has been generally taken at one million. The value of property in the city is rapidly increasing; it is increasing immensely.

3000. Then one-third of 50,000 *l.* will represent the sum of money to be raised by the fourpenny rate?—Yes; the rated value of the property in the city is rather more than a million; therefore a shilling rate, if raised on the actual rated value, would realise rather more than that sum of money than less.

3001. You stated that a fourpenny rate would raise 16,000 *l.*; you stated also, you have been reducing the rate; what is the present rate?—The present rate is 2 *d.* in the pound.

3002. How long has it been 2 *d.*?—It was reduced this year.

3003. What was it before?—Fourpence; I may state that the city have raised that rate 4 *d.* in the pound for a great number of years; they pushed on for these last 16 or 17 years the construction of the sewers, with all the rapidity that the enormous traffic of the city would enable them; and, owing to their having constructed sewers nearly throughout the whole of the city, they are now enabled to reduce their rate to 2 *d.* in the pound, and in all probability it will be still further reduced before long.

3004. Notwithstanding there is more demand for these sewers, you have been enabled to reduce the expense?—Yes.

3005. Mr. *R. Gurney.*] You are no longer incurring any great expenditure in the construction of sewers?—Just so.

3006. You were saying that you had considered this matter in conjunction with Mr. Forster; has it since been referred to you as a subject to consider in conjunction with Mr. Stephenson and Sir William Cubitt?—It has been referred to Mr. Bazalgette and myself to consider and perfect the scheme of Mr. Forster for the northern district of the Thames. Mr. Stephenson and Sir William Cubitt, being the consulting engineers to the Metropolitan Commission, of course it may be requisite for me to see them occasionally on the question.

3007. Are you of opinion, that at present you have sufficient information to decide on what will be the most advisable course to pursue as to the intercepting of the sewage?—Certainly not; it will be requisite before you can perfect a scheme, to have a large amount of detailed information it should be understood that Mr. Forster's scheme was to be subject to large modifications; but if you mean by your question to ask whether I have the information to prepare a perfect scheme that you could go at once to contract upon, I must answer certainly not.

3008. Is it also important you should know the results of certain experiments in order to ascertain what the value of the sewage would be before you determined?—I think, inasmuch as the value of sewage-water will determine greatly what shall be done in reference to the interception, that it would be expedient to wait until that is determined.

3009. Have you been down recently to Mr. Wickstead's works at Leicester, in order to learn how matters were going on there?—I have.

3010. Is that experiment carried on sufficiently far at present to afford you the necessary information?—It is not.

3011. Have you been in communication with Mr. Wickstead upon the subject?—I have.

3012. *Committee.*] Are there not a vast number of chemists at this moment who are experimentalizing on this question of sewage manure, and every day come out with some new scheme?—I have only heard of one or two modes of treating the sewage-matter, the lime process appears to be the only one that has obtained considerably among experimenters. Mr. Wickstead's works, at Leicester, are purely experimental works at present; they consist

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consist of three tanks, which might be capable of producing, provided they had sewage-matter, a small quantity of manure daily. Mr. Wickstead stated that he was about to commence works based upon his experiments sufficiently large to manipulate the whole of the sewage produced by the town of Leicester; but his mode of drying is novel, and he does not wish all his results to be known, because he wishes to have the value of his own experience and his own labour.

3013. Mr. *R. Gurney.*] Did you ascertain how long precipitating the solid matter took?—I saw the process, and was at the works some time; it appeared to me to take about three hours to do it effectually.

Cross-examined by Mr. *Caivert.*

3014. I believe you made a report, on the 24th of December last, to the City Commissioners of Sewers?—That is recently; a copy of the report I furnished your company with.

3015. Is that with reference to the present scheme?— Yes.

3016. I believe this is a passage in it: "The total interception of sewage from the Thames has been a result now long and earnestly desired. Numerous plans for effecting it have been from time to time projected, and the reason for accomplishing it have been felt to be sufficiently urgent to induce your Honourable Court to associate with the Metropolitan Commission in devising a scheme for that object, the expense of which was to be borne by the metropolitan householders and owners of property. Any well-matured plan which proposed to effect this by the agency of commercial enterprise, and without charge to the ratepayers, I submit, is worthy of your best consideration; and if found to be feasible, and to accord with those fundamental principles which may appear to you as needful to be strictly adhered to in such a scheme, worthy of your encouragement. The paramount obligation in such an undertaking appears to be the entire interception from the Thames of all the sewage now discharging into it, upon the line of the proposed sewer (rain-fall beyond a certain limit excepted), and capability of adaptation to the future metropolitan requirements of sewage and drainage; the provisions of this scheme for compliance with these points, as well as numerous others of large importance, it is impossible yet to investigate. I might beg, therefore, to suggest to your Honourable Court that you should give formal dissent to the Bill, as you will then be enabled at a future stage of the proceedings to propose those terms which you may deem needful for the protection of, or advantageous to, the public; and your dissent can be withdrawn at a fitting time, when you find all that you may require has been provided for or acceded to." That was your report?—Yes.

3017. May I infer that your opinion is, that the total interception of the sewage from the Thames is an object of very great importance?—Yes, it is; it is a work that should be carried out. I have told you before, I do not think that the metropolis is damaged to the extent that many persons imagine; but I think it is a fitting work to be carried out in this great metropolis.

3018. When you say that the present scheme is not sufficiently comprehensive, do you make that remark with regard to the plans brought forward by Mr. Forster, having a high-level sewer as well as a low-level sewer?—If Mr. Forster's scheme errs at all, it is in not being sufficiently comprehensive.

3019. It is not sufficiently comprehensive in not having a high-level sewer?—I think your scheme is not sufficiently comprehensive.

3020. Is it in that particular that you think so?—In that particular it is.

3021. Supposing a high-level sewer were added to the low-level sewer, should you then think the main principle aimed at by Mr. Forster sufficiently carried out?—If your low-level sewer formed part of a general scheme, comprising an upper-level sewer and a low-level sewer, it would be a more comprehensive scheme than it now is.

3022. Would it be comprehensive, according to your meaning of the term?—I think that your low-level line might, with considerable alterations, be adapted to form the lower portion of a scheme for the northern districts of the Thames; but the scheme must be looked at in its entirety; and, therefore, if it is essential that the upper-level, as well as the low-level sewer should be constructed, and of course the low-level scheme would be nothing without the upper-level scheme, it would not be perfect.

3023. My object is to get an explanation of the word you have adopted, "comprehensive;"

prehensive;" if you added the high-level sewer to the low-level sewer, would the objection in respect of want of comprehensiveness be answered?—Not entirely.

3024. In what other respect would it be necessary to make alterations?—I think it should be extended sufficiently to take all the sewage which is likely to come down on the district coloured blue, on the northern side of the river, and figured 44½ square miles.

3025. Where do you think this scheme ought to begin on the west side?—I am not prepared now to state to you what a perfect scheme should be; and if I answered your question, it would be telling you at once that I had a scheme thoroughly completed: I cannot do that; I can only tell you that I think it should be sufficiently comprehensive to take the sewage, &c. from that area.

3026. How long ago was it you were desired to consider this subject on the part of the City Commissioners, the general subject of interception?—About three years ago.

3027. In the course of three years have you not been able to make up your mind as to where the interception tunnel should run?—From the time of Mr. Forster's report on his scheme, until I looked at this subject again in reference to the scheme of your company, the matter rested; I thought very little about the matter. I have a large amount of business to do; and, of course, I cannot keep my mind entirely on the single question of the interception of the sewage of the town.

3028. You have not made up your mind where that should begin?—I am not prepared to tell you what will be a perfect scheme of interception; I have not made up my mind where the head of the lower line of intercepting sewer should begin.

3029. When did Mr. Forster make his report?—January 30th, 1851.

3030. Now, since January 30th, 1851, have the City Commissioners required you to go into the subject again?—No, not until I went into it with reference to this scheme.

3031. That was at an interval of about a year and a half?—Two years.

3032. Do you at all make up your mind as to the size at which the tunnel ought to be constructed?—For what district, the upper or the lower?

3033. The lower level: I will assume your plan of the upper level too. What should you say would be the size of the lower-level tunnel?—That is also telling you I am prepared with a perfect scheme: I have told you before I am not prepared to substitute one.

3033*. Answer yes, or no, whether you have made up your mind as to what the size of the tunnel ought to be?—No; I have a general idea of the size of that tunnel, nothing more.

3034. What is your general idea?—I think about 10 feet diameter might be sufficient; I do not at all pledge myself to that opinion; it is a general idea.

3035. Would you leave it quite uniform, 10 feet from end to end, or larger at one end than at the other?—Certainly; it should be graduated in size to the sewage it was likely to receive on its route.

3036. Would you take it 10 feet in the city?—I cannot answer that question precisely, but I should say certainly not: if it is 10 feet at its outlet, it would be useless to make it 10 feet in the city.

3037. You would make it less in the city than 10 feet?—I should.

3038. Your idea would be a tunnel, extending gradually from end to end, and being about 10 feet at the outlet?—Provided it formed a part of a more comprehensive scheme, combining an upper-level sewer, delivering by gravitation.

3039. That would be sufficient to carry off the sewage and a certain portion of the rain-water?—Provided the largest area marked on the map was carried off by the upper-level sewer, then probably the lower-level sewer, having its outlet diameter 10 feet, and its being properly increased in diameter at various parts along its route, might be sufficient.

3040. You gave us an account of what your view was of the hours of the day during which the sewage escapes; as I understood you, it was in six hours; you told us you assumed that; and then you said you had consulted with officers, and it was, to a certain extent, the result of your experience; may I ask you whether those observations are made with respect to your own district of the city, or with reference to the sewage outside the city?—They are formed with reference to the whole metropolis. I have my own observations in the city; I have had communications with the officers for the metropolis upon this subject, and, of course,

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upon all subjects connected with sewerage; and that is my conviction, derived from my own information, with respect to the city of London, and the concurrent opinions of other persons officially qualified to give opinions upon those points.

3041. What kind of officers?—The engineers.

3042. The engineers watching the works?—The engineers to the Metropolitan Commission. My own inspectors, clerks of works and assistants, and I think I mentioned before, if I did not I will mention it now, my own personal observation.

3043. I presume that your own personal observation applies to the city?—My own personal observation applies to the city only.

3044. Your clerks and different officers, who are subject to your authority, they apply to the city?—My clerks and officers keep within their own jurisdiction.

3045. The simple answer would have been yes?—The simple answer would have been yes.

3046. What other parties outside the city have you communicated with?—I think with most of the officers who have been connected with sewerage matters during the last seven years.

3047. What gentleman connected with other parts not within the city has given you information on the flow of the sewage in particular hours?—I have not been to any officer recently, but I have questioned as to their experience of the hours of the greatest flow of the sewers in their districts. But for the last seven years I necessarily have been in communication with the officers having charge of the sewers throughout the metropolis: like most men who have the same duties to perform, or cognate duties, we have discourse on those, and most other matters connected with sewers. My opinion is formed from what I have obtained from them in such conversations; and I will also, if you please, quote the opinion of Mr. Phillips.

3048. Who is Mr. Phillips?—Mr. Phillips was for a great many years Clerk of the Works to the Westminster Commission.

3049. Is he alive?—Yes.

3050. Is he in London?—I am not aware; I saw him a month ago; he may be.

3051. We may have him probably?—"The flow increases," says Mr. Phillips, "from early in the morning till noon."

3052. What are you reading from?—I am reading an extract from evidence given to the Metropolitan Sanitary Commission about four years ago.

3053. By Mr. Phillips?—Yes.

3054. What part of the town does he belong to?—He was the Surveyor to the Westminster District first, the Clerk of the Works, and then the Surveyor of the Westminster District. He says that the greatest flow is between 11 a. m. and 1 p. m.

3055. *Committee.*] That agrees with your own evidence?—It does; Mr. Phillips' opinions being deduced almost exclusively from the sewers in the Westminster district; my own personal observation, and the observations which I principally rely upon being drawn from my own district; and I believe a little consideration will show that that necessarily must be the case, that the flow would be about those times.

3056. Mr. *Calvert.*] Are not the habits of the city rather different from the West End of London?—The habits of the city of London are not different from any portion of the metropolis.

3057. Does not the escape of sewage depend on the hours of cooking?—Very little on the hours of cooking.

3058. What does it depend on chiefly?—It depends on the copious usage of water, that being among all classes of society principally in the morning, probably varying a little; of course there is a difference between the habits of the denizen of the East and the West End; but necessarily the largest consumption of water will take place in the morning among all classes.

3059. Now, you were understood to say, that the flow increases till 12 at one end of London, and then diminishes. Mr. Phillips' account is, that it is principally from 11 to 1?—Yes.

3060. Does not that show, to a partial extent, a little difference?—I have taken an

an average. I have told you between eight and two; I said six hours in the day.

3061. You said, a slight increase till eight, and then a great increase till 12; and then a diminution till two?—That will vary a little on the day of the week; but still I have taken six hours as the average of the greatest flow. In that time I consider one-half will come down.

3062. You mentioned the ballast that gets into the sewers; that ballast would be carried into the tunnel by the force of the water passing through the sewers?—The largest portion of it.

3063. Would not the whole?—Probably not.

3064. How could it get into the tunnel which is below the sewers, except through the sewers?—Certainly, it could not; I misunderstand you, or you misunderstand me.

3065. Then is it the force of the stream that passes through the sewers that takes it into the tunnel?—Yes.

3066. Would not the force of the stream, if it is sufficient to take it from the sewers into the tunnel, be sufficient to carry it down the tunnel?—Yes; I think it would carry it all down to Barking, if there is a velocity of two miles and a half in an hour. At the lower portion of your sewer you would have to raise it.

3067. That is part of the scheme laid before the Committee, you are aware?—Yes, I am aware of it.

3068. Do you approve of the circular shape of the tunnel?—I think it is the proper shape for a tunnel of this size, having such a flow of water in it constantly.

Re-examined by Mr. *Gurney.*

3069. You say, you have not quite made up your mind as to when the intercepting tunnels should commence?—I have not.

3070. Have you quite made up your mind that it ought to commence further westward than this does?—An intercepting line of sewer ought to go further westward than that does, or the sewers should be so adapted as to convey away all the sewage of those districts into it, which is the same thing, as it would be a continuation of the same thing.

3071. Ought they to carry off the flow of the Ranelagh Sewer, and the Counter's Creek Sewer, and the King's Scholars' Pond Sewer?—Yes.

3072. And there is no provision by this scheme for the relief of any of those sewers?—None.

3073. Do they carry down an immense quantity of the sewage of London into the Thames?—A large area of the districts draining into these sewers is increasing in population probably more rapidly than any other portion of the metropolis; the population is spreading in a north-western and western direction more rapidly than in any other.

Examined by the *Committee.*

3074. You have had a great deal of experience in constructing sewers; can you state what a circular 10 feet sewer, constructed in the Londay clay, would cost?—No, I cannot at once do so; I have not built sewers of so large a diameter as 10 feet.

3075. But you have repaired large Sewers; for instance, the Fleet Sewer?—I have repaired them; but the expenses of repairing are greater in proportion to the work done than the construction of new work. The repairs are made under highly disadvantageous circumstances.

3076. Can you not give the Committee any information which would enable them to judge of the sufficiency of the estimate for the construction of this tunnel sewer?—I have looked at the estimate only generally, and they do not provide sufficient for the reservoirs, I think, or sufficient for the steam-power; but I think the quantities taken out for the sewers, and the prices put against them, are reasonable; the works for converting the sewage, I conceive, must be exceedingly expensive, but as there are no details of them, I can give no opinion upon that point.

3077. You have been acquainted much with the repairs of sewers: if this sewer was constructed on proper principles, and with due inspection to see that it was properly constructed, do you think it would last for a long time without requiring repair?—A very great time; certainly a very great number of years,

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and then the invert would first suffer. If a small brick is out of the invert, other bricks are turned out one after another very shortly, while there is a high velocity. At the present moment, the London Bridge Sewer, from Gracechurch-street down to the Thames, has the whole of its keel course, or centre course, of bricks of the inner ring gone, and that sewer has not been constructed above 20 years; that is only one or two bricks in width.

3078. Is that a circular sewer?—It is an elliptical sewer.

3079. Then in an elliptical sewer, the force of the water would be greater?—The centre of the stream at the bottom has the greatest friction; the velocity varies at every inch of the depth. It will have the greatest friction and the greatest wear at the bottom; whatever quantity of sewage may be running in the sewer, the highest friction, it will sure to be at the lowest point. The lowest point is the centre.

3080. Then a circular sewer of the same capacity would not be so liable to be deranged from that cause as an elliptical sewer?—It would be about the same, when you are dealing with sewers of such a size, and such a quantity of water in them.

3081. Do you consider that sewer, when it was constructed, could be properly constructed, if, after the short period of 20 years, this serious damage has occurred to it?—I think that every practicable care was bestowed upon that sewer; but in any work which is subterranean, it is impossible to guard against the casualties of some imperfection of work; it is utterly impossible to do it; even if you have a competent resident engineer on the spot, you have the chance of a slight imperfection in the work: it is a difficulty that attaches to all work that is beneath the surface. I believe that sewer was constructed with the greatest possible care: it was known to run in a direction where it was essential that the greatest care should be bestowed upon it: it is by the side of the bridge, and is covered over with buildings of immense value and weight. And I know that every care was bestowed upon it; but nevertheless, the wear and tear of the water, and the numerous substances which are hurried over it, has gradually worn away the invent of that sewer.

3082. For the purpose of repairing the sewer, is it necessary that the sewage should be diverted into other sewers?—It will be impracticable to a great extent to do that; but, as far as practicable, it will be proper to divert it when it is necessary to repair that sewer. The sewer is not by any means dangerous; and it does not materially interfere with the flow of sewage in it; but it is in a state which requires the stitch in time, that is to save nine; and it will be necessary for the reparation to divert all the upland water, as far as possible, and construct troughs which will receive all the immediate sewage, and carry it over the heads of the workmen; but as nothing can guard against storms coming down, provision must be made in that sewer by which the men may leave their implements, and go out on to the river banks, or escape by some other means, upon such occasions.

3083. Supposing that such a sewer is made as that proposed by this Bill, in case repairs are required in that sewer, the same means could be adopted; the sewage could be made to pass away for a time in the present existing sewers, and such other contrivances could be resorted to as you have mentioned?—The sewer will be better situated for repair than those sewers which take off all the rain-fall, as such sewers must always do a certain amount of work. In this low-level intercepting sewer, by the aid of pen-stocks, they may shut off the sewage above the points where the reparation is needed; but in that case the sewage must go by the existing outlets into the Thames.

3084. For the purpose of repair, it will be more favourably situated than most of the large sewers in London at the present time?—They will be enabled to adopt those measures which will enable the work-people to work with greater facility certainly.

3085. Do you think the construction of this sewer would be attended, using proper care, with danger to the buildings of the city?—It would be impossible to say there is not a risk. You may take every practicable means on going through the blue clay, which is in some respect advantageous, and in some respects disadvantageous, as it is a very treacherous strata to go through, and you might have carried the sewer for half a mile through the city, or any other portion of the metropolis, and done so without the slightest accident, and the next 10 feet you might arrive at a different strata of ground, and have an accident. You might have water come in, and such a contingency, if there was sufficient water came in, it

it would oblige the men to fly, or probably, if it came in suddenly, it would bury the men; that is the greatest chance to which the works would be subject: in that case there might be a chance of some accident. But I do not think that, with great precaution, more than the ordinary per-centage of injury will arise to the houses on the line.

3086. Do you think it essential for the construction of an intercepting sewer, looking to danger to buildings, that it should be carried along a thoroughfare, instead of being carried under any existing buildings?—At the great depth at which this sewer, speaking of the sewer on the northern side, is situated, it will practically, with great care, matter very little. It is wiser to go along a thoroughfare, to avoid the buildings as much as possible, certainly; but, by so doing, it introduces curves in the sewer, making the sewer more tortuous, which is an undesirable thing in itself, if it can be avoided, I do not think it will practically make much difference where they are in considerable depth, and where they are in blue clay.

3087. Within that mile which you superintend, will it have to pass, do you imagine, through any other solid land than blue clay?—I believe that it would pass almost exclusively through blue clay. At one or two points they would be near the surface of the blue clay, which is the most treacherous portion of it; because there are undulations in the surface of the clay that are filled up with sand and gravel; and the blue clay being an impermeable strata, the water and the gravel are contained in those undulations, and form small lakes of water, gravel and sand. At the Fleet Sewer there would be considerable difficulty in passing beneath it. They are nearer the surface than at any other spot; and they are consequently nearer the more treacherous portion of the strata.

3088. There would be no great difficulty in determining the points where they were most likely to meet with these obstacles; you have pointed out one, the Fleet; would not a thorough consideration of it before enable them to anticipate the spots where the greatest difficulty is likely to occur?—If the Legislature ever decides that such a scheme shall be carried out by the company, of course the officers of the Commissioners of Sewers will place all their experience at their disposal as far as is requisite, that is, as regards the junctions of the sewers, and other matters connected with the district sewage. But I assume that no company would think of commencing a work of this sort without taking very careful boring throughout its entire length, and until that is done, and the strata ascertained, no line of sewer can be said to be finally determined upon. Mr. Forster's scheme, which took to the river shore at Blackfriars Bridge, would in all probability have had to be abandoned, because I have ascertained since then that a quicksand of considerable depth exists beneath the banks of the Thames at Blackfriars Bridge, and I have no doubt it runs along the Thames, in the front of Somerset House, and is a continuation of the same strata that was met with in the Victoria-street Sewer.

3089. I find from you, in the last year 8.000 *l.* is the sum that has been levied by the City Commissioners of Sewers for the purposes of sewage?—Last year it was 16,000 *l.*; it was only reduced in the present year.

3090. Now, have you been taking any steps for purifying the river in any way from the effects of the sewage of the city of London?—The City Commission granted Mr. Moffatt the sewers at Puddle Dock to experimentalize upon. It was, I believe, the intention of the Commissioners to secure him in his right to that sewage, if his experiment was successful; and not to allow him to develop the means of doing it, and then to drive him away. But the City Commission can take no measures for the escape of the interception by the sewers excepting in connection with the Metropolitan Commission, as they have neither the head nor the tail of such scheme; they can only do it in conjunction with the Metropolitan Commissioners.

3091. And beyond those steps you have mentioned, they have not, with the Metropolitan Commissioners, made any attempts to obviate this evil, great or small?—The City Commissioners have been very desirous of carrying out, or having a scheme carried out, for the purpose of the interception; and the Metropolitan Commission have been equally so.

3092. What practical steps towards effecting that object, beyond directing you to consider Mr. Forster's plan, and associating you with the engineer of the Metropolitan Commission, have been taken in that direction?—No steps beyond that.

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3093. What is the last Act of Parliament which regulates the City Commission?—I have it here; the City of London has had two Sewers Acts recently, one passed in 1848, and the other in 1851. The Act of 1851 was simply to obtain additional powers in relation to various sanitary matters, which the Commissioners found their first Act of Parliament, applied for in 1848, did not give them.

3094. What is the number of the City Commissioners?—Eighty in number.

3095. In what way are they appointed?—They are appointed by the Court of Common Council; they consist of an alderman from each ward; a common councilman from each ward, and a deputy alderman from each ward.

3096. What is the average attendance?—I think it may be taken at about 25.

3097. Monthly meetings?—Weekly meetings, with committee meetings in the interval; they meet about 100 times annually.

3098. Now, I understand you have had no application for fresh sewers within the whole of your districts?—No; we have had no application for sometime; directly an application is made, the sewer is ordered to be constructed.

3099. The whole expense is in the way of repairs?—And constructing such trifling sewers as may be necessary. The sewers'-rate will, in all probability, be still further reduced next year. There is the reconstruction of those ancient sewers, which are 400 or 500 years old, such as the old city ditch, which was arched over as every person thought proper to arch it over who lived on the side of it; the reconstruction of sewers of that description, and other inefficient sewers which have been left in their present condition until sewers were made into every one of those districts that were entirely without sewers.

3100. How are the mud banks in the course of the city districts now; are they materially diminished by the action of the steamers?—I have known the Thames the whole of my life, and I have no hesitation in asserting that the banks of the Thames get cleaner every year.

3101. Was that process going on before the steamers were plying?—I can recollect when a steamer was a sufficient novelty to induce one to rest on one's oars when rowing, and look at it, and there was more mud when there were fewer steamers.

3102. Do you extend that remark to the water?—Yes; the water does not look any dirtier than it ever did; that it necessarily must be somewhat dirtier is indubitable; but I do not expect there is any more effluvium from the water, neither does it look dirtier than it used.

3103. Your evidence is, that year by year the banks are improving, so far as any nuisance resulting?—For miles along the shores, with the exception of creeks or inlets to docks, there is no such thing as mud.

3104. How do you explain that?—Principally by the increased scour of the tide, resulting from the removal of old London Bridge, and also by the encroachment or projection of the wharfs, and by the gradual reduction of the water space, or rather the space between low-water line and the river-wall, and greatly owing, doubtless, to the wash from the steam-boats.

3105. Constant agitation of the paddle-wheel?—Yes; there is still some mud left at Whitehall, in the front of the Duke of Buccleugh's house, and a great deal by Cremorne Gardens, at Chelsea; but that, I fancy, has a different aspect to what it had some years ago.

3106. Has it ever entered your contemplation to extend the mouths of the sewers lower into the bed of the stream?—One of the city sewers, the Fleet, does already deliver by such means. Estimates have been made to the City Commissioners for performing that work to all; but inasmuch as that work would have been unnecessary, if the intercepting line of sewers was carried out, it has been put in abeyance for the present; but I have been every three months about to report the advisability of carrying out that work at once, and not waiting any longer.

3107. You recommend that?—Most decidedly. The large amount of the annoyance and complaint of the effluvium of the river is nothing but the reeking of the shores at the time of low-water under a hot sun, the main sewers that are shown upon the map before you, are by no means the only outlets discharging into the Thames in the city; I know 12 sewers which are termed outlets, upon the line of the city, but there are 40 or 50 other outlets; every one of these, at low water, discharges on to the banks, and the sewage runs from the point of discharge over the shore to the low-water line.

3108. Can you give us any rough conception of the cost of doing that with regard to these sewers, and can you state whether any practical objection would present

present itself to doing it beyond the expense?—Not the slightest practical objection, besides the expense. Mr. *W. Haywood.*

3109. Can you give us any conception of what the expense would be?—I can only tell you that, with regard to my own jurisdiction, I should think 2,000 *l.* or 3,000 *l.* would do the whole of those discharging on the line of the city shore. 13 June 1853.

3110. Would that carry them down to low-water mark?—To carry them below low-water mark, and it is a measure that I shall certainly advise to be done, unless I see some positive chance of the scheme of interception being carried out; it has been waiting solely for that for the last three years.

3111. That would also be a measure that would be in some respect desirable, even if an intercepting drain was constructed, because that intercepting drain would not, according to your own view of its capacity, carry off the sewage-water at all times; there would still be a frequent discharge?—It cannot be expected that any scheme will ever be laid down or constructed that will carry off the whole of the storm-water; but storm-water, although very dirty after the first showers of rain, is not so filthy as the ordinary flow of the sewage.

Robert Stephenson, Esq., a Member of the House, examined by Mr. *Henderson.*

3112. ARE you are Consulting Engineer to the Metropolitan Commissioners of Sewers?—Yes, I am, in conjunction with Sir William Cubitt. *R. Stephenson*, Esq., M. P.

3113. Were you for some years one of their body?—Yes, I was, for some years.

3114. Had the Commissioners of Sewers under their consideration the means of providing for the interception from the River Thames of the sewage matter?—Yes, they had; and before I was connected with the commission, the previous commission had advertised for plans from various parties, and they lay unexamined until the formation of a new commission, a member of which I was, and then a sub-committee was appointed to go into the whole subject, and to carefully examine all the proposals made by various parties, and there were 150 or 160 plans examined with great care, and reported on, and well considered; and upon the report of that committee, Mr. Forster, the then engineer of the commission, proceeded to design a plan for the general improvement of the sewage of London, and more especially with a view to the interception of it, to remove it from the Thames as far as possible in the vicinity of London. I was connected with Mr. Forster, at least I took a great interest in the question, and every step he took, I was cognizant of. I examined the greater part of London, and more especially directed my attention to the lower districts on the south side of the Thames, which are so badly drained at present, and which are, in fact, the seats of diseases of all kinds. We proceeded so far as to complete our plans for the south side, and were about to let the contracts; but a question was raised as to the powers of borrowing money, and pledging the rates of the districts. It was found we had no such power; therefore we had no means of proceeding with our contracts. We had then an interview with Sir George Grey on the subject, with a view of bringing a Bill into Parliament, to authorise us to raise money for those purposes. Very shortly after that interview, the Government was changed. I do not know what steps were taken by the next Government, but I believe none, and I believe none are now being taken by the Government to relieve the Commissioners of Sewers from their embarrasments. It is utterly impossible for any commission, however competent they may be, or however anxious to go on with the improvement of the drainage of London on an extensive scale, without their powers being altogether altered.

3115. Their pecuniary difficulties are too great?—Yes; they are absolutely prohibitory.

3116. You are aware that the first Act gave a power of rating to the amount of 1*s.* in the pound?—Yes; and another incident came into play which tied up our hands so completely, that we could hardly even maintain the drainage as it at present existed. Mr. Henley moved in the House, that the power of levying the rate be reduced from 1*s.* to 3*d.* However, the thing was so absurd, that a compromise was made, and we were given the power of raising 6*d.*

3117. It was reduced to 3*d.* by one Act, and raised to 6*d.* by a subsequent Act?—I was not aware of that. I was in the House at the time that Mr. Henley proposed to reduce it to 3*d.* However, there we are, and there we have been;

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our hands tied, exposed to the obloquy of incompetency and indisposition to improve the drainage of London, when we really had no means of doing it.

3118. Now, are the funds sufficient for the drainage works, and for making the sewers that are necessary?—The present powers are insufficient to supply the new demand and to maintain the old; I am considerably within the mark when I state that.

3119. Can you state to the Committee why Mr. Forster's plan for the interception of sewage from the Thames was not carried into effect?—For the reasons I have just been giving, that we have no means of getting money.

3120. Do you consider the drainage, so far as it is incomplete or imperfect, or the interception of the sewage from the River Thames, is more important to London and its neighbourhood?—I do not mean to underrate the principle of interception at all; but there are so many defective portions of London at present, that I think the money would be better spent in improving the present system of drainage, keeping in view always that it is to be intercepted eventually, because the system of intercepting drains, beyond all doubt, is the only means of making the lower portions of London at all manageable. At present the floods that fall, say at Hampstead, are partially absorbed and partially carried away by other drains, and by evaporation also. But when it gets covered with houses, and paved, all that water will come down to the bottom of London, towards the River Thames, half-an-hour after it falls, or at least an hour: that is the great difficulty that London is now suffering from. Drains that were perfectly competent to drain London when it consisted of two bands of habitation on each side of the river, are now totally inadequate. Therefore, I feel that I had better at once explain to the Committee, although I am an advocate for interception, I think the present suggestion is beginning at the wrong end. I think that we ought to begin by intercepting the sewers above. The lower parts of London would take care of themselves very well. The major part of the present pollution of the Thames might be removed by a simple system of interception, having proper inclination. Three-fourths of the north side might be drained by gravitation: that is, I think, the first thing which ought to be done; this ought to be the last. This map is so divided as to represent the districts that may be drained by gravitation, and those that must be drained by pumping. On the north, this red colour comprises a very large proportion of the whole area of the north side of the Thames; that admits of a sewer falling four feet a mile, commencing at the extreme west of London, Bayswater, and continuing to the River Lee, where Mr. Forster proposes that there should be reservoirs, if necessary, for the purification of the sewage; but that would be conveyed into the Thames conveniently at all times. Therefore, there would only be this very narrow band next to the river to be conveyed into the Thames. On the south side again there is a district of something like 21 square miles, a greater portion of which may be said to be under high-water mark, and therefore must be pumped. But in order to render pumping available in these low districts, it is necessary to put an intercepting drain immediately above them, to prevent the inconvenience of land floods. But you do not keep off the land floods, although you do adopt the interception system of drainage. You do not clean the Thames of pollution; every shower that falls would overpower the sewers, and lodge the filth in the Thames. After a month of dry weather, when the ordinary quantity of water that is supplied is not quite sufficient to prevent the sewers from getting filled up, therefore, when rain does fall very rapidly, the very time when you want the sewage to be carried out, it is lodged in the Thames as before. Therefore, an intercepting system, beginning at the low end, and going up to the top, is just the converse of what I should recommend. I should begin at the top, and leave the bottom, and go on towards the bottom. I do not at all object to this system of intercepting or pumping (I think we shall be driven to it); but I think, as I said just now, it will not answer either the object of the parties who are entering upon it, and I am quite sure it will not cleanse the Thames of any pollution, or very little, on account of what I have just now stated. So that during the month of dry weather, although they discharge partially, they get silted up gradually, and depend on a flush of water cleaning them out. When the flush of water comes, then there is no intercepting sewer that you can put. I defy any one to put an intercepting sewer there that will at all relieve the Thames from the bulk of that filth which may have been accumulating for a month.

3121. *Committee.*] As you have stated where you would put the upper intercepting sewer on the north of the Thames which will carry off the water by gravitation, on the south of the Thames where would you propose to put the intercepting

intercepting sewer, which should also I imagine carry off the flood water by gravitation?—There is a contour line there on that map which shows pretty nearly where the intercepting sewer on that side of the river ought to be put.

3122. Is that the open sewer that you contemplate?—It was intended to be an open sewer. When it was discussed before the Commissioners in Greek-street, we did propose, for economy's sake, to make an open sewer.

3123. But there are great objections to that?—No, scarcely objections; because that intercepting sewer would scarcely bring any sewage-water; it would be clear water from the country.

3124. That would, as I understand, save you from having to pump all the rain-water that would come down in flood-time?—Yes; but then the idea of pumping that is perfectly ridiculous. It only gets away now by the flap of the sewers being open about eight hours in the day, and that would be the same thing with the water that falls in storms over that area. To show how hopeless it is to anticipate that pumping would relieve that portion of London from the drainage of the floods, at the south side of the river it is estimated that the ordinary discharge of the sewage-water is about 5,300 feet a minute. Now, supposing an inch of rain to fall in that district (on the south side), we have had two inches to take; therefore take the maximum of two inches. I do not mean to abide by that; but I mean to show how unimportant any pumping is, compared with what would fall. There would be 4,700,000 cubic feet to discharge. The pumping power, or the delivery power, of the tunnel is proposed at 5,300 feet; therefore, if you take the maximum, I admit it is a maximum or thereabouts, the pumping power on the south side of the Thames would only be about 1-900th part of the rain-fall. It may be said that I am taking an outrageous case; but, taking it at half or a fourth part, it shows that any attempt at pumping to do away with the flood-waters, is quite ridiculous; therefore it is absolutely essential to begin at the top with your intercepting drains. If you begin at the low level, you must begin with an inordinate power for pumping. If you make your intercepting sewers afterwards, you do not want the pumping, and all the power is lost. Therefore it may prolong the period of pollution, I admit, protract the period when London will not enjoy good drainage; but still the best way is to look at what will be the best thing ultimately.

3125. Mr. *Henderson.*] You have anticipated a great many questions, but there are a few more to which I will draw your attention; you have said that a large amount of drainage is still required, that is, more sewers are to be made?—A great many more.

3126. If the funds of the Commissioners were equal to it?—Yes; those are sewers of an ordinary character.

3127. Explain the distinction between interception and drainage; they are two distinct things?—They are quite distinct things; the drainage of a district has reference merely to the conveyance of the sewage-matter to the lower level; and interception is then the process of catching it at that level.

3128. You have carefully considered the plan of this proposed company: suppose the plan carried out successfully, would that more effectually drain the neighbourhood of London?—No; it is not proposed by the parties to improve the drainage.

3129. It would have no effect on the drainage?—No effect whatever.

3130. Whatever sums were taken from the Commissioners of Sewers for the purpose of a tunnel would be so much abstracted from the funds applicable to necessary drainage?—I think it would be a most injudicious mode of spending the Commissioners' money to aid in this measure by a guarantee, because there are so many parts of London at present suffering seriously from want of effectual drainage.

3131. Looking to sanitary considerations, do you think the carrying further of drainage or interception more material?—The improvement of the drainage decidedly.

3132. This interception is partial only both with respect to area and the sewers it intercepts?—It may be called partial or not; it is partial as regards the extent over which its influence will reach.

3133. It takes only a part of the sewers that it intercepts?—Only a part; a very small portion, I think.

3134. State how far you consider the company's scheme, if carried into effect,

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would effect what it professes to do?—As regards the purification of the Thames?

3135. Yes?—I do not think it would effect that, except to a very small degree indeed. I have explained already to the Committee that the sewers get cleaned out when there is a pressure of water, and at the time this sewer would not have capacity enough to carry it away, nor would their power of pumping be at all adequate, therefore it must go into the Thames. I consider the great flaw of the scheme is omitting to take advantage of gravitation over the largest portion of London. I do not think that any scheme at present ought to involve the Commissioners of Sewers, or the City Commissioners, in an expenditure of money, without having that brought into play by the action of gravity.

3136. You are aware of the degree of care and supervision required for drainage works?—Yes.

3137. What do you think is the degree of supervision required for the work now proposed, assuming it to be under the joint supervision of the officers of the Metropolitan Commissioners and the City Commissioners?—That has reference to a point I wish to explain. One of the great objections made to the commission was its extraordinary extravagance; the Commissioners spent as much as 40 per cent. per annum on the cost of the works for their superintendence.

3138. *Committee.*] Are you speaking of the present Commissioners of Sewers, or the late?—They are both the same; the same remark will apply to both. I turned my attention very carefully to that point. It did strike me as very remarkable that engineering works of an ordinary character should absorb so large a per-centage on their construction merely for superintendence; I found that it was unavoidable. I began that investigation believeng I should reduce the cost most materially; but I found, instead of that, that it would be better to increase it, and for this reason: the works are carried on in small amounts scattered all over London, and therefore your superintendence must not only be vigilant, but you must have a man upon the spot all the time to see that it is fairly done. If it is done without an inspector it gets covered up, and you do not know what sort of work you get for your money; it is essential to have inspectors in great numbers; even for a job which may cost only 50 *l.*, it may require 20 *l.* for supervision. It is not the per-centage on the expenditure of money by the commission, but it is the per-centage on the total amount spent in making the sewers of London. Now the Commissioners of Sewers do not make half the sewers in London; all the builders have to build their own new sewers and drains in all the new portions of London. The Commissioners of Sewers have not only to superintend what they do in the way of repair in the heart of London, but they have to superintend and watch the construction of sewers by builders; therefore if the per-centage was fairly carried out, it should be put, by adding to the expense which the builders incur, as well as that which the Commissioners incur. It is easy to have vestry meetings and speeches about the extravagance of the Commissioners. I went into the matter with a view of reducing it myself; but I found it a very thankless office, and therefore was very glad to get rid of it. There was no opportunity for bringing your attention or ability to bear on it. It is very easy to carry resolutons at vestry meetings to the effect, that the Commissioners are incompetent men, and do not attend to it. I felt the injustice of those remarks; but I had no means of replying to them, and I now avail myself of this opportunity, that the public may get at the right information. I think it a favour of the Committee to allow me to do so. It does not quite appertain to this subject, but I am anxious to explain away the obloquy which I think the commission has so unjustly laboured under.

3139. *Committee.*] As to one point, regarding the construction of sewers by builders; when a builder lays out a new square, or a new street, he is bound by law to construct sewers for that street?—He is.

3140. He may either construct the sewer himself, under the inspection of the Commissioners, or he may pay to the Commissioners such sum as they require for the construction?—Precisely.

3141. Either of those?—Yes.

3142. In most cases is it the practice that he constructs the sewer himself, or that he transfers money for the construction to the Commissioners?—I believe the practice is usually with great builders to construct them themselves, under our supervision.

3143. Do you believe you get as good a sewer constructed, if it is constructed under

under the supervision of the Commissioners, as if it were constructed by them?—If the superintendence be vigilant; it requires very vigilant superintendence.

3144. Of course it very much increases the cost of inspection?—No doubt.

3145. Mr. *Henderson.*] Suppose the work of this company were done under the general supervision of the officers of the sewers, and the officers of the company, have you turned your attention to what amount of supervision would be necessary?—No, I cannot say I have; it is a difficult work, not an impracticable one; but it would require the closest superintendence. I am not prepared to say that the work would fail when done, if done as it is proposed; but I should have some apprehensions if I was engineer of it, and I should make some experiment before I began it. It is a novel notion to put a tunnel so deep to withstand a pressure, as the Committee have heard, of something like 40 tons per lineal foot occasionally. It is entirely a new thing with regard to brickwork. As regards cast-iron there would be no difficulty at all about it; but the construction of the arch makes it so incompentent to bear a thing of that kind, that I have my doubts about it; I will not say positively, but I fear the repairs and wear and tear would be very great in the work, because the bricks all radiate towards the side from whence the pressure comes. Now, when they radiate from the outside to the in, then, of course, every brick is a key-stone to its neighbour; but the other way, as we all know, in floods very often bridges are blown up from a slight pressure beneath. Now, I do not know that the tunnel would fail; if there was a constant and uniform pressure, there would be less danger in my mind in the bricks getting loose; but there is a varying pressure; first of all the earth pressing inwards, and then the water pressing a little outwards; you must bear in mind that that is going on. The inside pressure is very small compared with the outside; I admit that.

3146. *Committee.*] Would not the outside pressure be your great security against the danger of an inside pressure, which you admit is the most formidable, from the less resistance which the work itself offers to it?—I say the outside pressure being so much larger than the inside pressure, is the only safeguard, if you have any cavity left, and I defy you to make a tunnel without many.

3147. Leave the question of the inside pressure out of account, and assume that you were putting in a 10 feet diameter tunnel of the thickness here proposed, and that it was not to be subjected to internal pressure of any sort, should you then be afraid that that tunnel would not, being a circular tunnel, be able to resist any pressure exercised on it?—It would resist it certainly.

3148. You would have no apprehension if it were done well?—None at all.

3149. That being so it is a protection against the inside pressure to which it will be subjected when the tunnel is charged with water?—Yes, the only protection that can possibly keep it in order.

3150. Is not the tunnel safer the deeper it is?—I was not at all saying that an objection arose from its depth, excepting indirectly, that in consequence of its depth it got the great pressure upon it from the inside.

3151. But in the same proportion it will be sustained by the external pressure?—No doubt.

3152. You do not apprehend much on that score; it is merely a question whether the thickness is sufficient?—Yes; certainly I should increase the thickness very much; it ought to be laid with hard bricks and cement.

3153. Are many of the sewers that are constructed now made with hard bricks?—They are made with what they call ordinary burnt bricks; and there is a superior class, called glazed bricks.

3154. For this tunnel should you adopt some hard bricks which are not at present in use?—Harder than the ordinary brick. I began the Primrose-hill tunnel with the best ordinary burnt bricks, but they failed; they were crushed, and I was obliged to adopt paviour bricks: they almost reached the point of semi-vitrification, and there is a brick very similar made in Staffordshire, called the blue brick. I believe a work of this kind ought to be made with bricks of this kind.

3155. Would you make the whole of the tunnel of that, or only the invert?—No, the whole tunnel.

3156. And cemented?—Yes.

Cross-examined by Mr. *Calvert.*

3157. I believe you approved of Mr. Forster's system of tunnel?—No, I did not; I approved of his system generally.

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3158. I have got an account of a meeting, in August 1850, of the Commissioners of Sewers; present, Viscount Ebrington, Captain Dawson, Mr. Hawes, Mr. Hardwicke, Mr. E. Lawes, Captain Harness, Mr. Stephenson, M.P., and Sir J. Burgoyne; and there is a very able speech by Mr. Stephenson?—No doubt; Mr. Frank Forster's scheme was got up under my direction.

3159. Did you not approve of his scheme, which referred to the tunnel?—No, I did not; I always objected. I left this country when Mr. Forster's plans were almost advanced to completion. I was in Egypt about four months; and in the interval Mr. Forster had finished his plans almost in detail. He had introduced a line of tunnel from Westminster down to the city, along the river side. I left this country, having expressed to Mr. Forster the strongest objection I possibly could to that line. I said the difficulty would be possibly insurmountable. Captain Veitch at that moment had a strong prejudice in favour of that line; I as strongly objected to it. But in my absence, I believe, Mr. Forster did fall into Captain Veitch's wishes, and he took his tunnel along the river. To that part of Mr. Forster's scheme I decidedly objected.

3160. Did you not object to it because it was so close to the river?—Yes, and unfavourable ground.

3161. Does not ours avoid that, by being further from it?—I think yours is better.

3162. I will read a part of Mr. Stephenson's speech at this meeting, at which Mr. Frank Forster's report was read: "I will not now go into the details of the works, as Mr. Forster has already explained them; and I shall move, that Mr. Forster's report be adopted, and that the works therein recommended be carried out forthwith;" did not that include making the tunnel?—It certainly would include that. As far as Mr. Forster's report was concerned, it was adopted; but it was not adopted and carried out in its integrity.

3163. Mr. *Henderson.*] This is the south side, is it not?—Does this report refer to the south side of the river, or to the north; I really do not know which.

3164. Mr. *Calvert.*] "With respect to the low-level tract, coloured blue, on the general plan, it is proposed (commencing, as before, at the lifting point on the eastern bank of the River Lea) to construct a sewer at a depth of 47 feet below the invert of the high-level sewer, proceeding beneath the River Lea, near to Four Mills Distillery, taking the north-western bank of the Limehouse Cut, at which point it receives the branch intended to intercept the sewage of the Isle of Dogs; thence continuing along the bank of Limehouse Cut, through a portion of the Commercial-road, Brook-street, and beneath the Sun Tavern Fields, into High-street, or Upper Shadwell, at a point opposite to the church; thence along Ratcliffe, Highbury, and Upper East Smithfield, across Tower-hill, through Little and Great Tower-streets, Eastcheap, Cannon-street, Little and Great St. Thomas Apostle, Trinity-lane, Old Fish-street, and Little Knight Rider-street; thence beneath houses in Wardrobe-terrace, and on the eastern side of St. Andrew's-hill, along Earl-street to Blackfriars Bridge. From Blackfriars Bridge it is proposed to construct the sewer along the river shore to the junction of the Victoria street Sewer at Percy Wharf, which sewer, between Percy Wharf and Shaftesbury-terrace, Pimlico, becomes thus an integral portion of the intercepting line"?—I think it is not fair to the learned Counsel that the parties should prompt him in that way. It is not Mr. Frank Forster's report. Here is a meeting of the Commissioners of Sewers, at which I was present. After the minutes of the proceeding were read over, then comes the report from Mr. Frank Forster, headed, "Surrey Drainage;" and it is after the report is read that I get up and move its adoption. It has no reference to the tunnel on the north side of the Thames.

3165. Are you not aware that we are discussing a tunnel on the south side, as well as on the north side?—Yes.

3166. That tunnel proposed to you is the south side?—Yes.

3167. The formation of the tunnel is to be made on the south in the same way?—Your tunnel on the south side is removed from the river, and follows the direction proposed by Mr. Forster; and to the south side I do not object, provided you adopt a system of interception, which I say is a necessary preliminary to any deep drainage scheme being carried out for London.

3168. We were on the construction of the tunnel itself and the brickwork; that was the question we were referring to. With respect to that, is it not to be constructed in the same way, whether it is on the south side or on the north?—I believe

I believe Mr. Forster's first tunnel was on a much higher level than that proposed by yourselves, and therefore less difficult. Your tunnel on the north side would be much more easily made than Mr. Frank Forster's.

3169. Is it better by being lower than Mr. Frank Forster's?—It is more away from the river.

3170. With respect to the level, is it better in its position by being lower than Mr. Frank Forster's, or worse in that respect?—If it is lower, it is worse.

3171. If a tunnel 15 feet lower still is recommended, you disapprove of that recommendation?—I do not know that I should, if the circumstances were such as to lead me to believe that was the best level. It must depend upon a consideration of the locality at what depth you would make your tunnel: I cannot answer that as a general question.

3172. With respect to the construction of the brickwork, as far as that is concerned, the question is the same, whether on the north or south side?—I did not attach much importance to that: it is a work of great difficulty; I have no doubt of that at all. There is not anything insuperable; I should not venture to say that. I trust you will refer to that paper again on the Surrey sewage.

3173. If I understand you rightly, you think that the first work to be undertaken is the work of drainage, and not the work of interception?—Yes; that is my opinion.

3174. How many miles of drainage should you complete before the work of interception is commenced; do you know at all?—I think the interception ought to be begun simultaneously on the north of London. I think that ought to begin first; on the south side of the Thames, in Bermondsey, and that low district, it is three or four feet up to five feet under high-water mark. I found it so bad, that I recommended that no time should be lost in carrying out Mr. Forster's proposal to drain it.

3175. *Committee.*] On the south side?—Yes; therefore we began it the first thing. But the interception was always an object, in my mind, of the greatest importance; and if on the south side it had not been so deplorably bad, I should have recommended the interception system there.

3176. Mr. *Calvert.*] May not an interception drain in a town be compared to a main drain through a rural district, which you generally construct before you make the ribs for draining water down into it?—I should say so.

3177. Is it not the usual rule to ascertain which is the drain that constitutes the outfall, before you lay out the adjoining drains that shall pour their tributary streams into that main drain?—No doubt.

3178. Would it not be the proper course to make your high-level intercepting drain, and after that, to make the several sewers which pour their contents into that drain?—That appears very natural. I will explain the difficulty you find yourself in directly. You are making a deep drain for the purpose of receiving all the drainage of London, setting it down to a low-level, and having to pump it all up again. If you will only draw a contour line round the north of London, it will take three-fourths of the whole sewage away, without pumping at all, more efficiently than this low drain, or any pumping apparatus you can put up.

3179. I was asking the question with respect to the high-level drain; would it not be the right course to be constructing the two systems continuously, the high-level drain and the low-level drain, instead of constructing one before the other?—If you had the means of doing it, no doubt.

3180. Suppose, for instance, the Commissioners had had funds when that report was made, would they not have directly set to work, and constructed the intercepting drainage?—No doubt.

3181. *Committee.*] Which?—I mean the intercepting drainage that would have carried away the material, the sewage, by gravitation.

3182. On the south side?—On the south side you must pump.

3183. You stated that the plan on the south side was completed?—Yes.

3184. And that you have actually proposed to enter into contracts?—Yes, we had; that was not for the intercepting sewer; it was a sewer going through a dense portion of Lambeth and Bermondsey that was so infamously drained, that I determined to recommend to Mr. Forster that we should begin there really by effecting improvements in the worst part of London, by taking the worst part first.

3185. That was to be discharged into the Thames?—That was to be pumped and discharged into the Thames.

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3186. That was at a very low level?—Yes.

3187. The sewer very much taking the line that this plan proposes to take for the south side?—Very much the same; essentially the same.

3188. And much of the same dimensions?—Yes.

3189. Mr. *Calvert.*] And working on the same principle?—Yes.

3190. Now, with regard to the upper level, had there been funds, you would some years ago, when the report was made to the Commissioners, immediately have commenced the upperl-evel intercepting tunnel?—That was not a tunnel; it was proposed to be an open drain, a catch-water drain.

3191. But with a view to catch the sewage, do you approve of catch-water drains?—The catch-water drain there would not bring down a large amount of sewage, but a large amount of fresh water; therefore it might be conveyed by a long and open drain without injury to the neighbourhood.

3192. Would it be a very expensive operation a catch-water drain?—Yes; it was a very expensive operation.

3193. Do you recollect at all what the calculations were of the work which was then projected?—I cannot charge my memory on it; I did not go into it, Captain Veitch did; I had some interviews with him on the subject; it was a very large sum.

3194. He having a catch-water drain on the north side, was not to receive sewage?—On the north side it was to receive two-thirds of the sewage of the north of London.

3195. Then I have misunderstood you; then the upper level on the north side is to receive the sewage as well as the rain-fall?—There is no system that will receive the rain-fall altogether.

3196. It was intended to receive the sewage?—Yes.

3197. If you had had funds, should you not have commenced the high-level tunnel, and also the low-level tunnel?—Very possibly.

3198. Would it not be expedient to carry on the two systems at the same time?—I do not think it would. I should like to see the effect on the drains of the low part of London consequent upon the complete interception of the upper portion.

3199. How long would it take to effect the interception of the upper part?—It would be dependent upon money.

3200. Suppose you had funds?—I do not think the intercepting sewer on the north side of London, as proposed by Mr. Forster, could be done in less than probably four or five years.

3201. Suppose the work of the low-level sewer were undertaken, assuming the same time it would take about the same period?—It would take longer a great deal.

3202. I am afraid there would be plenty of time for trying every experiment with respect to clarification before it could be brought into operation?—Yes; but those experiments hitherto have not been marked by success.

3203. I believe Mr. Forster proposed an expense of 1,000,000 *l.* on the north side?—I believe more, 1,200,000 *l.*

3204. The two systems were a million and a half, or a million and a quarter?—Yes, it would cost more than that.

3205. And that money was to be raised at four and a half or five per cent.?—I do not think we proposed any per-centage; I do not remember.

3206. I do not know whether you have read this report of Mr. Haywood and Mr. Bazalgette?—Yes, I have.

3207. There is this passage: "Having now described generally the scheme of the Great London Drainage Company, it appears to us expedient to submit to you information as to the points of variation between it and the plans prepared by a former engineer of the Metropolitan Commission (Mr. F. Forster), those plans having received the approval of both the Commissioners for the Metropolitan Sewers, and for the city of London." Did they receive such approbation generally while you were a member of the commission?—Yes; I remember we held several meetings; deputations from the City Commission met the Metropolitan Commission in Greek-street; we discussed the plans, and they were generally approved.

3208. There was no formal report adopted in a formal manner, but there was a sort of general approbation?—Yes; but you must always bear in mind, that I

objected

objected decidedly to the position which Mr. Forster adopted for his tunnel on the north side of the river.

3209. I believe that report involved a million and more for the north side?—Yes.

3210. Can you give an opinion as to what the high level would cost according to Mr. Forster's proposal?—No, I cannot; I suppose it will cost about that; the whole cost on the north side would be that; it was assumed at 1,200,000 *l.*; what the division was, I cannot say, but a large proportion would be to the lower sewer; that is a work infinitely more difficult.

3211. Of course, the expense of that, and the interest, and so on, must be paid out of the rates?—Of course it must.

3212. And for that purpose the Commissioners require further powers from Parliament?—Just so.

3213. And it was the want of those powers which prevented their undertaking the work at that time?—Undoubtedly.

3214. Do you think the high-level sewer could be done for half a million of money?—I cannot take upon myself to say that; I do not think it would.

3215. It would not be less than half a million?—I should be prepared for more.

3216. Suppose you were required to name a round sum, according to your general knowledge, what figure should you put, as nearly as you can give a fair estimate at the present moment?—It is a question of property; as to the engineering question, I could give you a notion at once; it would probably cost 15 *l.*, or 20 *l.*, or 30 *l.* the yard, but it would depend on the nature of the compensation.

3217. Separating the engineer's work from the compensation; but with regard to the work itself, what kind of sum should you think?—I should say more than half a million of money.

3218. Therefore you may put it at more than half a million, besides the compensations?—No; I beg pardon; as a mere engineering question, it must be a vague answer, if I give one; it depends on so many circumstances that I have not before me just now: I went into it with Mr. Forster, and just now I would rather take his figures than any vague statement of my own.

3219. Mr. Forster does not give us the figures distinguishing one tunnel from another?—I cannot give it to you.

3220. *Committee.*] Do you remember now the length of sewer from Bayswater to the Lea?—I do not exactly remember; but it was nearly eight miles.

3221. Then do you recollect what the size of the sewer was decided?—I could not charge my memory with it now; I think it would be very likely 8 feet by 5, or 5 feet 6, or something of that kind.

Re-examined by Mr. *Henderson.*

3222. If the funds had been found to carry the scheme into effect, would they have combined the tunnel and the high level with the system of drainage; would it administer to the drainage?—It would not at all administer to the improvement of the local drainage, but it would carry away the sewage from the low part of London, where it descends now, and inconvenience the lower sewers by gravitation, and would remove it from the Thames: that was one of the great objects that we had in view.

3223. This scheme would not affect the drainage at all?—Not at all; it is a system of interception merely.

Examined by the *Committee.*

3224. When were you first appointed one of the Commissioners of Sewers?—I think about 1846.

3225. That was the time of its first creation?—It was after the original commission was broken up.

3226. After the Sanitary Commission was broken up, they constituted a Commission of Sewers?—Yes.

3227. And then you were one of them?—Yes.

3228. That commission was again altered some years afterwards?—It was.

3229. When was that last act altering the form of the commission?—In 1848.

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3230. In 1848; could you tell me how many Commissioners of Sewers there were appointed to act?—I think there were 11 or 12; one of them never took his position; he died shortly after the appointment, and his place was never filled up at all; his name was Captain Alderson.

3231. Up to the present time it has gone on with the same number?—Yes; but I think the quorum has been altered.

3232. Do you happen to know what constitutes a quorum?—I believe it is five; Mr. Woolrych says two.

3233. Can you say over how many square miles the Metropolitan Commissioners have power for rating purposes; over how many square miles their jurisdiction for rating purposes extends?—I do not know the area exactly; but I should think it is a radius of something like 12 miles round the centre of London; that would be 114 square miles.

3234. Those districts that are comprised within the 114 square miles require a very different expenditure for their drainage, one from another, do they not?—Very materially.

3235. Did you hear the evidence of Mr. Haywood, of the city of London?—I did not.

3236. Mr. Haywood stated that the city of London, which comprised only one square mile at present, were satisfied, and were able to carry on their works with 2*d.* in the pound; now, for the 114 square miles, from your evidence you want a much larger sum?—A much larger sum.

3237. Now, looking at the interests of the various parties who occupy these different districts, do you think it right that there should be one uniform rate raised over the whole district?—No, I do not think it is proper; but still I think the present system in London extremely bad, very bad indeed; the best buildings are the lightest rated. I think it is very unjust, because the sewers in the lower parts of London have both their own duty to do, and the higher portions too; for instance, Bermondsey is a poor district, and there they cannot afford a rate, or at least scarcely. It would be a severe infliction upon them to put on such a rate as would carry out a perfect system of drainage in that part of London now. The upper portions, within certain distances, I think, ought to be charged more heavily for that than their own immediate wants would appear to justify; but then they are, I think, interested in the salubrity of the districts lying below them; therfore the division into parishes seems to me the most unjust thing possible in the rating for sewers.

3238. Then you think, for the sake of justice, it would be necessary to subdivide the town into other districts with a view to a sewer-rate?—I think so; that I felt all the time I was a Commissioner; I felt that every charge that was made bore unjustly in some quarter or other.

3239. Does not that seem to you, then, a reason for having limited the amount to be raised by the present commission until we got a redistribution of the districts?—I think it is; it prevented their going on with many improvements which were much wanted, while we were negotiating with Sir George Grey, when we found ourselves embarrassed by having no funds. I should certainly have brought it forward; and I know other Commissioners thought with me, that the mode of rating ought to be revised.

3240. Now, you have mentioned Bermondsey as a poor district, lying at a low level, which would have to contribute largely to the rate?—Yes.

3241. Now, on the other side, there is the city of London, a very rich district, with a very low rate?—A very low rate.

3242. If, on the one hand, it would be fair to relieve Bermondsey from the rate, would it be equally fair to put something on the wealthy side of London?—I think I should be disposed to do it, certainly. I think they are very much interested, the city of London, in keeping the districts of Bermondsey and Lambeth in a healthy condition; and I think they ought to pay for it.

3243. For the purpose of carrying out a good system of drainage, do you think it desirable that there should be two separate jurisdictions, one of the Metropolitan Commissioners and one of the City, or that it should be blended under one commission?—I am giving an opinion off-hand; I have always looked upon it as an anomaly; and I see no difficulty in joining the management.

3244. How often do the Metropolitan Commissioners of Sewers meet for business habitually?—We used to meet once a week; but we had sometimes special meetings in the interval.

3245. As well as the executive business of the commission, they have to hear appeals on questions of rate?—A great number.

3246. Do you think, looking to the interest of the commission, that it would be desirable to separate the executive business from that which is of a more judicial character, namely, considering rates and appeals?—We did make an attempt, by dividing ourselves into committees, to make that subdivision; for it was felt by those who were then, like myself, professional men, that it was a waste of time, and interfered very much indeed with our arrangements, and I could not attend those appeals. If any engineering question was brought forward, then I made a point of attending, and so did Sir William Cubitt.

3247. Do you think the question of rates might with advantage be entrusted to some other court, before which the Commissioners of Sewers might be fully represented, so as to see that justice was done to the public on the one hand, as well as to the individual who appealed on the other?—I never heard it put that way before. I should be rather afraid, although the two things appeared to be very distinct from each other; yet there are other points of contact which so bind them together, that I do not think an absolute separate jurisdiction would quite do. I think a body composed of some professional men, capable of advising on scientific or engineering points, associated with some other men of business, who might be paid, because the time spent in listening to appeals is immense; and there are many of them trivial, yet they must be attended to. I think a certain number of the commission might be deputed to do that: I think it will hardly do to make it a distinct or separate body.

3248. It does at present, as I understand, take up a large portion of the time of the commission?—Very large; the chairman's time is taken up entirely by the appeals and presiding over their meetings; he is continually employed, I believe.

3249. In the year 1850 you gave directions to the engineer to prepare a report for the drainage of the north of the Thames, having at that time received his report for the drainage of the south of the Thames?—Yes, it was so.

3250. And in those instructions you called his attention to these different points: first, "To keep the River Thames, within the metropolitan districts, free from sewage at all times of the tide;" next, "to provide an escape, by means of intercepting drains, for so much of the sewage of the north side of the Thames as admits of being so carried off;" next, "to raise all other sewage by artificial means, so as to deliver into a main channel for removal in accordance with the foregoing resolution;" and, lastly, "so to construct the intercepting sewers as to secure the largest amount of effective drainage, without having recourse to artificial means"?—Precisely.

3251. From your subsequent experience, are you of opinion that these works are as desirable now as you conceived them in 1850, when those instructions were given?—Quite so; more so; as London extends, that system of drainage would become more and more necessary.

3252. Then, increasing the district drainage and sewage, in your opinion rather increases the necessity of this intercepting drainage than diminishes it?—Certainly.

3253. You say, assuming this Bill were disposed of, the position of London would be this: the Commissioners must ask for powers to raise more money before they could undertake any work whatever?—Certainly.

3254. To obtain that, they must go to Parliament for that purpose; if they obtain power from Parliament to raise more money, the first application of that would not be, according to your view, in the intercepting of sewage, but the improvement of the system of sewage, and the extension of it?—They would go on simultaneously.

3255. Assuming you get funds to do both?—No doubt.

3256. But a large sum must be expended in extending and improving the system of sewage before it is brought to anything like the perfection which you think it ought to be?—Yes.

3257. Two millions of money have been stated; is that more than your opinion, or are you prepared to give an opinion?—I have discussed it with Mr. Bazalgette, the engineer of the Commissioners, and I believe his statement to be a fair one, that there are a thousand miles of sewers constructed, and a thousand miles more required.

3258. Assuming you had not the means of carrying on both together, do you agree with him in thinking that that is a matter of primary importance, and that

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the first application of your money ought to be the improvement of the sewage?—Most unquestionably.

3259. Then, again, the next step, assuming you had not money to carry on all together, would be laying down the high-level sewer?—Yes.

3260. And, lastly, you would come to the low level?—Yes.

3261. You have stated, that you would be disposed to introduce into the city of London, that has now got a twopenny rate, a more uniform rate, and you would extend that to the rest of the metropolis according, to your view?—Yes; I think, taking a large view of the question, that it ought to be more equally distributed over the whole population than at present.

3262. We find the Metropolitan Commissioners and the London Commissioners sitting very harmoniously here in opposition to this Bill; do you believe the City of London Commissioners would be ready to be rated uniformly with the metropolitan districts, the one being now not able to fulfil all its duties with a sixpenny rate, and the other having a twopenny rate, with a prospect of removal; do you expect they would come into such agreement?—I do not know that they would.

3263. Being elected by the common council, what is your opinion on that subject?—I think it is very probable they would be dissentient; but that does not alter in my view the justice of it; unless the Government are prepared to take it in hand, the sewage of London will daily get worse.

3264. If you had an intercepting drain on the north side, would not the sewage carried down that drain be much more diluted than the sewage of the lower portion?—No, I do not think it would; the amount of sewage would be in proportion to the number of houses; then the quantity of water supplied would be also in proportion to the number of houses, or nearly so. I will assume that the two will be pretty approximate. Then the daily quantity of water being about 60,000,000 of gallons, each area of London would be diluted to the same extent; at present the city of London gets the manure and the water from the higher as well.

3265. That was leaving entirely out of account, which probably you intended to do, the quantity of rain-fall?—Just so; you must deal with the sewage in ordinary weather, because that is when the parties, if they do make anything of it at all, must try and get it under those circumstances, and not when it is diluted with rain.

3266. Now, we are told by the city engineer, that during the whole of his experience, year by year, the banks of the Thames are becoming less and less offensive, and the accumulation less; is that in accordance with your own belief?—My impression is so: I think, with the exception of some cases, where the sewage has been rather concentrated in hot weather, I have sometimes felt it offensive at spots. There is one near Hungerford, to which my attention was called, and there is one higher up; but, taking the shores of the river generally, looking back for, say 15 years, my impression is, that they are rather better than worse.

3267. You do not at all ascribe that to the circumstance, that the sewage matter is more diluted when it comes in now, owing to the abundant supply of London?—No; the Thames has been getting deeper in consequence of the removal of London Bridge.

3268. And the agitation of the steamers?—Yes; that contributes its effect.

3269. Do you think that the removal of Westminster Bridge, and the substitution of such a bridge, and such arches as will be substituted in its place, will have a tendency to the same effect?—Doubtless; every old bridge taken down, and a new bridge put up with larger spans, offering less resistance to the tidal water, will improve the Thames.

3270. We should look for a further improvement from that?—I think the probability is, that you may have to raise the banks up a little about Battersea.

3271. What is your opinion of the effect of carrying out the present sewers to the low-water mark, or the point below low-water mark, not intercepting the sewage-water?—I believe it will remove, in a great measure, all the complaints that have been made.

3272. You agree entirely with the city engineer, in thinking that it ought to be done, if there was not some scheme of this sort?—Yes; but that ought to be done if there is a scheme of this sort.

3273. Because a large portion of water must find its way by the present communication

munication with the Thames, even if those intercepting drains were established? —No doubt, in times of rain. *R. Stephenson*, Esq. M. P.

3274. What would practically be the great evil if that were done, of which the community would complain if all the sewers were carried out to the low-water mark; what would be the great practical grievance of which London would have to complain from the absence of intercepting drains?—I do not believe myself the inconvenience would be very great. 13 June 1853.

3275. We have ascertained by evidence what the quantity of sewage and foul water in the sewers is in the bed of the stream, intermixed with the whole current; it would be very small indeed, very small: all those remarks I ask the Committee to bear in mind; I conceive them as having reference to the north side.

3276. I am speaking of the north side?—The south side you must improve, and you cannot improve it except by pumping from a low level.

3277. Then your belief is, that if the sewers on the north side were extended in the way which you are speaking of, that, as far as the great grievance to the inhabitants on that side, the smell between the periods of high and low-water mark would be reduced?—Very much indeed.

3278. That would be the more so in proportion as the tidal water was increased? —Yes.

3279. Now, the expense of that would be perfectly immaterial as contrasted with the expense of the intercepting scheme?—The cost of that would be comparatively very small; I think the engineer must have meant 2,000 *l.* each outlet.

3280. Assuming that to be the cost of each outlet, the expense would be very small indeed as compared with any system of interception which might be adopted? —Very small; I dare say 100,000 *l.* would go a long way towards it on the north side.

3281. And you think that if money were forthcoming, that ought to be done under any circumstances?—I think it ought.

3282. According to that view, ought you not to commence with that work. If it should be done under any circumstances, ought not that to be the first work, to see how far anything further is necessary?—Yes; if I were a Commissioner, I should urge that that be done by all means; but we have been so hampered for want of funds, that we could not do that; and there are local patches, densely populated places in London, that have no district drainage.

3283. Do you think Barking Creek is a proper place to establish a reservoir; do you see any necessity for going beyond Bow Creek?—No; there is no necessity for going beyond that.

3284. Assuming it as a commercial enterprise of trying to separate the water and the manure, there could be no objection to letting off the pure water at Bow Creek?—None at all.

3285. And in any case there must be a lift; if you abandon the commercial part of the operation, and let the foul matter flow into the Thames, there must be a lift, whether you go to Barking Creek or the other creek?—Yes; but there will be less lift.

3286. And the lift will be less at Bow Creek than at Barking?—Yes.

3287. And therefore, assuming it were necessary to have recourse to a covered channel, it would be better to lift at Bow Creek into a high-level sewer, even if a covered one were necessary, instead of carrying the whole of this deep tunnel to that point?—That was the plan that Mr. Forster and I agreed upon as the best.

3288. And the pressure will be the heaviest, of course, at the lowest part of this four miles?—Yes; but there is a difficulty which has not come out in this examination that occurred to me long ago, and it is a very serious question indeed; those low tunnels ought to be tried with care and caution; for during floods, it is supposed, it is known in fact, that the velocity of the current in a sewer falling four feet a mile, supposing it to be half full, or two-thirds only, would be about two and a half miles an hour. When floods come, and the sewer is charged to its full bore with water, and when we should naturally expect and wish for a larger scouring power, because the current that the sewer yields under ordinary circumstances is equal to the power of the engine at the far end, the current and the power must be in equilibrium, and then it is two and a half miles an hour; but as soon as the sewer gets filled, and overpowers the pumping engines, instead of having a greater velocity, which we always wish for, in consequence of the rain,

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we get a less velocity, because the sewer is filled to its full bore, and yet it can only get rid of the same contents of matter which it got rid of when half full with a given quantity of power at the end of the sewer.

3289. What evil do you apprehend from that?—Silting up those low sewers during wet weather, when you have the speed reduced from two and a half miles an hour to two and a quarter. Now, if two and a half were deemed necessary to carry away sewage-matter in the first instance, under ordinary circumstances a mile in half-an-hour would certainly be inadequate to carry it away during floods. It is during floods that the water ought to have the power of carrying it away. Looking to the other case, when it is carried away by intercepting sewers, where gravity alone acts, the sewers which run into that sewer form a head of water, and not being limited by the outfall, because you can increase the velocity of the water in that proportion as the rain falls, it will get more and more head in it. Therefore, in the one case, where you depend on pumping, the velocity of the stream is reduced; whereas, in the other system of intercepting the high level, the velocity of the stream increases; consequently it carries away all the soil much more efficiently, and cleanses out the sewer itself. Therefore the tendency of the one system of sewage of intercepting, would be self-clearing, and the other would be accumulating dirt.

3290. Do you apprehend that by any one storm, or any unusual commotion, there would be a silting up, and that it would not scour itself out again?—Yes, we find it on the south side; there is a large expenditure there in taking the solid sediment out of the sewers, which are filled up in some places during two-thirds of the day.

3291. That is an objection that the tunnel, which you think must be had recourse to on the south side, is as liable to in the scheme of the promoters?—Yes.

3292. That is a difficulty which you suggested, without knowing how to grapple with it?—Yes; but I should confine the low tunnels to where they are absolutely necessary; for instance, on the south side of London.

3293. I think you told us that the area of your jurisdiction extended to 12 miles round London?—Yes.

3294. And that your present rate is 6*d.* in the pound?—We have the power of levying that.

3295. Which I presume you exercise, as your funds are so low?—We have not the power of exercising that 6*d.* uniformly.

3296. It is only particular parishes?—Yes.

3297. Are there not, in the course of those 12 miles, a great many parishes which derive no benefit whatever from many existing systems of sewers at the present moment?—Yes.

3298. And that is the case on the south side, not only at Bermondsey, but Mile End and Bethnal Green?—There is a very bad sewers' system that wants improving, and a large sum of money laid out on it.

3299. Is it not the case with some portions of London, that there are no sewers whatever?—Yes, there are some parts of Bermondsey without sewage properly so called; they are open ditches.

3300. There are open ditches every where?—More or less.

3301. And you levy your rate in those places just the same?—Yes; we levy that rate in Bermondsey, if we want to expend the money in Bermondsey.

3302. We heard from Mr. Bazalgette, that there were about 1,000 miles now wanted?—Yes, pretty nearly that.

3303. Are these appeals upon the ground that they do not get sufficient benefit from the rate?—That is one of the heads of appeals. Another is, perhaps, over-charge, and objection to the amount: one has left the house, and is charged for the house he left.

3304. But the great portion of appeals arise from people saying they do not get commensurate benefit?—I think a considerable number.

3305. Is there any appeal from the Commissioners to the quarter sessions?—I believe not.

3306. It is the ultimate court?—Yes; I am not aware of any appeal.

[Adjourned till To-morrow, at Twelve o'clock.

Martis, 14° *die Junii*, 1853.

LORD SEYMOUR IN THE CHAIR.

Isambard Kingdom Brunel, Esq., called in; Examined by Mr. *R. Gurney*.

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3307. WAS the scheme of the Great London Drainage laid before you?—it was.

3308. Were you requested to report on it for the information of the Commissioners of Sewers for the city of London?—I was.

3309. Have you likewise had laid before you the report of Mr. Bazalgette and Mr. Haywood?—I have.

3310. Have you examined into the scheme in considerable detail?—Yes; but more the general bearing of the scheme than the details; I have examined sufficiently into details to enable me to form an opinion on it.

3311. Does the scheme appear to be one calculated to effect its proposed object?—I do not think it would effect any great change, so far as the public are concerned, in the drainage of the district which it is intended to serve; I think it may effect one of the objects that is proposed, that of taking for manufacturing purposes a large quantity of the sewage; I do not think it does that in a way which would effect any great change beneficial or otherwise to the district.

3312. *Committee.*] As to the purity of the Thames?—As to the Thames, it would to some extent, of course, diminish the amount of impurity that drains into the Thames; but I do not think it would effect that complete change in the state of the Thames which is sought for, inasmuch as during a great number of days in the year, and on many occasions, the greater portion of the impurities must still go into the Thames.

3313. Mr. *Gurney.*] Is the impurity of the Thames such as is in a great measure caused by the sewers, that do not communicate with this tunnel, the Ranelagh Sewer?—A great many above the district that is proposed to be served by this, would, of course, still go into the Thames.

3314. In your opinion, ought any scheme of interception to provide for those sewers?—If a scheme of interception is attempted, of course the more complete and extensive it is, the better.

3315. At any rate, ought it to be so laid out as to be able in future to be adapted to those sewers?—I think the levels and the arrangement of the scheme ought to be such, in the first instance, as will admit of its being extended both in capacity and extent to the district which it has to serve.

3316. Ought it, in your judgment, to provide for the increase taking place in the metropolis?—I think so, because any such system, in the first instance, will, to a great extent, exclude the future application of any other system, and therefore the arrangement of it, in the first instance, should be such as to admit of considerable extension in dimensions of surface.

3317. Ought it to provide for any portion of the rain-fall?—My own opinion is very decidedly, that any system of interception will be almost mischievous rather than beneficial, unless it is sufficient to provide for the rain-fall to a very great extent; if it can do it wholly, of course it may be better; but that perhaps may not be possible.

3318. Would one low-level sewer, in your judgment, be sufficient to carry off the sewage, and such portion of the rain-fall as ought to be provided for?—No; one single low-level sewer of ordinary practical dimensions would not, I think, be sufficient to carry off safely and fully the rain-fall, as well as the sewage; it would become overcharged on a great many occasions, and would be almost mischievous rather than beneficial.

3319. I do not know whether you have formed any opinion as to what amount of rain-fall should be provided for?—My own opinion has always been, that you ought certainly to provide for at least half an inch in the 24 hours; there are 15 or 20 days in the year in London on which the average fall of 24 hours is more than that, or as much, and of course that falls, generally speaking, in much less time than 24 hours; and therefore a system that would only take off an average of half an inch in 24 hours, would still be insufficient for probably 20 or 30 days in the year.

3320. I do not know whether you have gone through the calculations as they

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appear in the report of Mr. Bazalgette and Mr. Haywood as to the power that would be necessary to carry off the amount of sewage and rain-fall?—I just checked them; they are very simple calculations, and they seem to be correct; but those powers would not, of course, be nearly sufficient to take off any moderate allowance of rain-fall.

3321. What horse power would be necessary at the reservoir to discharge the whole amount, or to lift the whole amount which would be brought by the tunnel, if full?—Assuming 19,000 cubic feet per minute to be the delivery of the 10-foot sewer, it would require about 2,000-horse power to lift it the 58 feet.

3322. Now, supposing this plan were carried out, does it, in your opinion, improve the general drainage of the metropolis?—No; it could have no beneficial effect on the general drainage of the metropolis; as simply draining off to this low-level sewer, instead of draining off into the Thames, would, of course, leave all the details of the drainage exactly the same, and I think the running contributory sewers coming from different levels into one sewer at a low level, and therefore connecting them all, would practically involve some very considerable difficulties.

3323. Then did you advise the Commissioners of Sewers not to concur in this plan?—I did.

3324. Do you still remain of opinion that it is not desirable for them to concur in the plan?—Yes. I think the plan would be prejudicial, inasmuch as, of course, the large capital expended on that plan would of necessity practically, whatever might have been the exact wording of the Act, preclude, for many years to come at all events, the expenditure of money on that which might be found to be perhaps a more beneficial plan.

3325. *Committee.*] Did you make any report in writing to the Commissioners on this plan?—I did.

3326. Mr. *Gurney.*] Is this it, Mr. Brunel?—Yes.

[*The following document was directed to be inserted on the Minutes:*]

18, Duke-street, Westminster,
26 May 1853.

Gentlemen,

I HAVE, in compliance with the request conveyed in a letter from Mr. Daw, of the 19th March, considered the project of the Great London Drainage Company, so far as I have been enabled to do so by an examination of the deposited plans and sections, and the Bill brought into the House of Commons by that company. I have also read the report of Messrs. Bazalgette and Haywood.

Although I do not propose to enter into a discussion of all the details of the plans, but shall rather confine myself to a general opinion upon the question of the propriety of supporting or opposing the measure in its present shape, as affecting the interests of the district under the charge of the Commissioners of Sewers for the city of London, I have, before forming my opinion, entered into a consideration of these details, and have maturely considered how far the execution of the proposed works, according to the general principle indicated by the plans and by the Bill, might be modified, so as to render the work, as a whole, as beneficial as possible to the district under your jurisdiction; and I have endeavoured also to consider how far it might be practicable, by stringent conditions and by protecting clauses in the Bill, to secure to the public the advantages which might possibly arise from the complete success of such a work, considered as an experiment, without at the same time entailing upon the public the risk of any serious evil consequences from the entire, or even from a partial failure of the undertaking; and I should observe, that I have entered upon this inquiry, and have considered the subject, not merely with a total absence of any prejudice against it, or against the principle of allowing a private Company to attempt to serve the public even in so essentially a public measure as the drainage of the city, but, on the contrary, with a great desire to see the principle fully carried out, of leaving all requirements to be supplied by the free and unrestricted efforts of private enterprise, stimulated by a fair and legitimate expectation of profit.

The result of the fullest consideration I have given to the subject is, however, a decided opinion that it would not be for the public interest that the measure in its present shape, and in the present stage of our knowledge and experience of the subject, should be allowed to proceed.

It seems to me that the measure is much too vast and too comprehensive, and in its practical effects, if completed, too monopolizing for an experiment, or as a measure which can be considered as a step towards further and progressive improvements; while, on the other hand, if no doubts are to be entertained of its perfect success, even to the fullest extent of the objects professed to be sought by the promoters, the benficial results to the public are too limited and restricted.

The only change proposed to be effected by the work, so far as the public is concerned, is, in fact, the diversion from the Thames and into another channel of the sewage, at most times, but not in cases of storm or unusual excess of rain; the work in other respects effects

no

no improvements, and offers no facilities for improving the system of drainage, but, on the contrary, introduces several new difficulties; it offers no easy means of extension, should the system be found advantageous, but, on the contrary, by the nature of its construction, its capacity is limited to that which may be given in the first instance.

The bargain or contract proposed to be entered into with the public, appears also to me to be one-sided, and might possibly prove very disadvantageous to the latter.

By the provision of the Bill, the sewage, or so much as the company find it advantageous to take, is sold to that company; and no improvement, or any new system involving the abstraction of that sewage, could practically be effected by the public: in fact, the public is committed for a long term of years to the bargain; but even if it be assumed that all the actual outlay of capital is at the risk of the promoters, and that whatever may be the ultimate cost, they are able and willing, or can practically be compelled to provide the money, and incur the necessary expenses of efficiently completing and maintaining what they undertake to commence, their confidence will not secure their success; and if eventually the conversion of the products should not prove profitable, no compulsory law will, or possibly ought, to secure the continued and efficient operation of the work at a loss, while the enormous outlay, and consequent loss to the enterprising speculators, the very serious inconvenience which the public must sustain during the execution of the works, and the length of time that may elapse before the final result of the experiment is conclusively ascertained, may possibly, for a very long time, deter others from attempting more limited, and, in the end, more successful measures admitting of progressive extension and improvement, or may postpone for an indefinite period any more complete and general measures to be undertaken by publicly constituted authorities.

If the pecuniary profits to be obtained by the collection, and conversion to useful purposes, of the sewage of so vast a city as London, are to be considered as certain and large, then I consider that the advantages to be secured to the public by the sale of these profits to one or more private companies, should be much greater than any that are promised by the present measure.

If, on the other hand, the success of the measure is speculative, the indirect evil consequences of a failure are too serious to be risked by the public.

I agree entirely in the observations of Mr. Bazalgette and Mr. Haywood as to the necessity that any scheme of interception should be adapted to the probable future requirements of the metropolis, and that it ought to be capable of extension and improvements.

I think also with the reporters, that it is essential that the rain-fall should, if not wholly, yet to a great extent, be provided for. Upon these two important points, I think the proposed plan essentially defective and objectionable, without committing myself to the opinion that it is impracticable to render a single and low line of intercepting drainage efficient for all levels of an undulating surface like that of London; yet I consider that the attempt involves immense practical difficulties, which are in no way provided for in the present scheme, and which no restrictive or compulsory clauses could in any way provide for.

I agree entirely in the observations of the report under the head of "general conclusions," as to the scheme of the company, and also in the concluding words of the report, that "it is highly expedient to await the result of further experience as to the means to be employed, and the advantages to be obtained in the conversion of very large quantities of sewage into a saleable product."

Such being my very decided opinion upon general grounds as to the expediency of sanctioning the measure at the present time, and in its present shape, it seems to me unnecessary that I should enter into a discussion of the objections which appear to me to exist to many of the details of the plan, and which could only be properly discussed on the assumption that the general principle of the expediency of the measure was admitted.

I am, &c.
I. K. Brunel.

To the Commissioners of Sewers of the City of London.

3327. *Committee.*] You see no reason to alter the opinion expressed in that report?—No; I should observe that on writing that report, and subsequently, it so happened, that I have had no communication whatever with Mr. R. Stephenson on the subject of this Bill; but I yesterday heard his evidence upon it, and I concur entirely in every view expressed by him on the subject.

3328. Are you one of the Commissioners of Sewers?—No, I am not.

Cross-examined by Mr. *Hope Scott*.

3329. If I understand you, you think it desirable that provision should be made for rain-fall of half an inch?—I think that should be the least.

3330. Upon what area do you take that?—The whole of the area that would run into any such drain.

3331. Why have you fixed upon half an inch?—I stated the reason; because there are 15 or 20 days in the year upon which more than half an inch falls; therefore, unless you provided for about half an inch, you would have a very large number of days in the year during which the intercepting sewer would be of no use.

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3332. You do not think of providing for those 15 or 20 days, although it exceeds half an inch?—I should think about it; but it might be too costly to do so.

3333. Supposing the tunnels to be capable of carrying half an inch, do you think the construction of them would be an advantage to the metropolis?—If properly laid out, I think it would.

3334. But without this power of dealing with this half an inch of rain, you think it would not be advantageous?—I think the advantage gained by merely taking off the sewage from the Thames would be very small, unless you did it for 330 days in the year, or some large number of days.

3335. Do you mean that taking away the sewage as distinct from the rain-water would be no benefit?—You cannot distinctly separate them when they are once in the sewer.

3336. Surely there must be some point at which sewage-water passes by, almost pure rain-water during storms?—I do not understand you.

3337. In which the contents of sewers change from fecal sewage-water into almost pure rain-water in the course of a storm before you attain to half an inch of rain-fall in which the discharge of the sewers must become almost pure water?—To talk of the discharge of sewers becoming pure water, is to speak so very relatively, that it must depend on how you use the term, and how I use it; the more rain-water there is, the more dilute it will be. I do not know how I can give you any other answer than that.

3338. And the longer it rains; have you considered any other scheme for relieving the Thames from the impurities of the sewage of London?—I am acquainted with various schemes that have been proposed; I have never proposed one myself.

3339. I have not had the advantage of reading your report; have you contemplated any practical mode, except by such sewers as these?—I have only contemplated these projects that have been before the public.

3340. I think you approve generally of the report submitted to the Commissioners of Sewers by Mr. Forster?—I never expressed any opinion about it, I think.

3341. You approve generally of the report of Messrs. Bazalgette and Haywood?—Yes.

3342. With respect to the horse power necessary to meet the full sewage, you put it at 2,000?—I say if 19,000 feet were required to be lifted 58 feet, that would require 2,000-horse power.

3343. That would be a capacity; there is no particular capacity of pumping power specified in the Bill?—I do not think there is.

3344. *Committee.*] You assume what Mr. Stephenson did, that the lift will be 58 feet?—Yes.

3345. The report says that the depth of tunnel at the extremity will be 49?—I did not remember what the dimensions stated in the report were. I took the 58 as given to me, and therefore I said assuming 58 feet.

3346. Do you contemplate the banks of the reservoir being added to it; you will see at Barking Creek 49 is the depth of the invert?—That only tells me that the sewer is 49 feet underground.

3347. How would the other be met?—I do not know; I took 58 as given.

3348. Mr. *H. Scott.*] We admit it to be 58, for the purpose of passing it into the tanks. Now, with regard to the fact of any such intercepting drains on the sewage generally, no doubt, on the south side, it would be very much advantaged by a low-level sewer?—I should think it would.

3349. You have spoken about the expenditure, and alluded to one of the objects in this Bill interfering with the more beneficial expenditure hereafter; what expenditure were you pointing to particularly?—I did not refer to any particularly; but I said any expenditure for any plans that might hereafter be formed; and that this did not effect any public good, although it might be advantageous or not to those who removed the material.

Examined by the *Committee.*

3350. You said you agreed generally with Mr. Stephenson's evidence?—Yes.

3351. Do you agree with the evidence which Mr. Stephenson gave as to the expediency of carrying the existing sewers further into the Thames, with a view of

of preventing the disagreeable effects that arise from them as they are at present?—I do; I think a very great improvement indeed will be effected by that, and at a comparatively small expenditure.

3352. With regard to the scheme now before the Committee, and your observations respecting it, do you make any difference in the tunnel on the north side of the Thames and the tunnel on the south of the Thames; do you consider that one may be more advisable than the other, or that they are both objectionable as they are proposed?—I think that the tunnel on the south side may be more easily made the means of effecting a public benefit than that on the north side. I still think on the south side it would be almost essential to the well-working of such a system that there should be another intercepting means for taking off the amount of rain-fall.

3353. Such as Mr. Stephenson has pointed out for taking off the water that falls from the higher level?—Yes.

3354. But, looking at the very low level there to be drained, do you think that some sewer at a low level is not necessary for the draining of that district?—Unquestionably it is essential for the draining of that district, quite independent of any advantage of intercepting it from the Thames, but simply because it is too low to drain effectually into the Thames; therefore some low-level drain there is essential for the mere drainage of the district.

3355. Now, should you apprehend any danger from the construction of a tunnel sewer, such as is proposed here, north of the Thames, going through all those streets of London at that depth?—I think it should be kept clear of St. Paul's and any public buildings decidedly, because I do not think that a tunnel would be executed at that depth at ordinary prices, without in all probability having some accidents and some contingencies. Of course, I admit it to be quite possible to execute a tunnel of that sort without in any single case allowing the ground to swell or to sink above it; but I think, if executed at a moderate price, and therefore by contracts in the ordinary way, that you cannot calculate upon a long length of tunnel at those depths being made without some casualties, and, therefore, that it would be desirable to keep it out of the way of any valuable public buildings.

3356. You have executed a great many tunnels; have you ever carried any under any town?—Yes.

3357. Where?—Dudley.

3358. At what depth?—Varying from a slight depth to a great depth there; from 20 feet below the streets, to a considerable depth.

3359. To double that depth?—Yes, more than that a good deal.

3360. Did that affect any of the buildings above?—Yes, a good many.

3361. What soil was it in; can you tell now?—I do not now recollect; it is some few years ago: part of it was in the coal-measures; I think mostly rock; but we damaged the houses above a good deal. Tunnels are now executed with great skill by contractors and others; yet there are very few cases where they have been carried on without damaging the property above, very few.

3362. Now, have you formed any opinion as to the part of this scheme which refers to the drying of sewage, and converting it into a fertilizing material?—I have hardly been able to form an opinion upon it. I do not think we know enough yet to be at all convinced that it is possible to do it profitably, particularly in very large quantities, and where it will be delivered out at one spot; I can imagine more easily in small towns and remote places in the country that it may be; but still I think it is a question to be decided whether very large quantities can be produced and sold, so as to be profitable.

3363. The inclination of this tunnel, you probably know, is four feet fall in a mile?—Yes.

3364. Is that an inclination that you approve of, or do you think it is sufficient, or would more be necessary, do you think?—I really have not thought much about it. I should think so; it was a very good inclination, I think quite sufficient.

3365. Now, to drain the upper district, which you say ought to be provided for in any plan, you must start at a lower level than the level at which these parties start, and pass under the Victoria Tunnel, instead of being on a level with it. The head of the tunnel must be at a lower level than the present head of the tunnel, if it is to be extended so as to drain the upper district westward?—Yes.

3366. Therefore, keeping that inclination to the terminus at Barking Creek,

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there would be a considerable addition to the depth of the tunnel?—Yes, if there is the same inclination kept.

3367. That, of course, would very much aggravate the expense of pumping the sewage?—Yes, assuming the same amount of sewage.

3368. Still, taking half an inch, making provision for half an inch of rain-fall per day, and having a tunnel of that capacity, would also very largely indeed increase the quantity of sewage that would have occasionally to be pumped up?—Yes; it would be beyond all practicable limits to provide for half an inch of rain-fall, and to keep it at that low level.

3369. On account of the expense?—The enormous size and expense of every thing.

3370. Do you express an opinion that an intercepting drain running in anything like the direction of the lower intercepting drain here is one that practically cannot be undertaken?—Not to be made large enough to take the rain-fall of the district which would run into it.

3371. The half inch; and without being made so large, you thought it would be mischievous, rather than otherwise?—I think it would.

3372. Therefore, practically, such a scheme may be abandoned?—Yes; I think, making a single low-level intercepting sewer for the whole of the northern district of London is an impracticable plan.

3373. Now, how would the case be altered, if you had a high-level intercepting sewer combined with the other; that, of course, would very much diminish the necessity for a capacious lower one; but still if you are to make provision for half an inch of rain-fall on the intermediate district, there would still be a considerable addition required to the size of this tunnel?—I am not sure of that. If this tunnel were to be be directed exclusively to the lower-level, and all the rain-fall and sewage from the higher level intercepted by neither.

3374. And extended westwards?—With the extension westwards, then, I should think; I have not made the calculation; it would be required to increase this.

3375. You have not so far considered it in detail as to be able to give an opinion?—No.

3376. What, in your opinion, would be the effect on sewers under ordinary circumstances of cutting off all the rain-fall of the higher district; would not that be to render the sewers in the intervening space during a great portion of the year extremely foul?—If you were to intercept only the rain-fall.

3377. Suppose you intercept the sewage and rain-fall?—Then you would have on the lower district only the sewage and the rain-fall of that district. With the artificial supplies of water, which, although small, are regular and constant; and the rain-fall of that district, my impression is that you would have sufficient.

3378. As regards the upper portion, the portion lying nearest to the higher level, there would be the least quantity?—They would get the rain-fall of the back country which drains into them; the part that would probably have the least rain-fall to help it in that case, would be just the band between the upper intercepting drain and the lower receiving one. In that district, what with the artificial supplies of water, which, although small, are regular and constant, and the rain-fall of that district, I should think there would be sufficient.

3379. Do you doubt that considerable advantage results to the existing sewage from the constant flush of heavy rain from the large district?—No; I think very great advantage results from it. Still I think it most likely that if we had to keep that lower district drained by itself, it could be done; that is my impression.

3380. Now, you state that you cannot give me any near estimate of the size that would be required for the lower-level tunnel, assuming it was to carry half an inch of rain-water of the district intervening between it and the high level; yet you admit it must be larger than the present?—Yes.

3881. Of course, the larger the tunnel, the more difficult and dangerous the construction of it?—Yes; the danger would increase rapidly with the size.

3382. The tunnel would also lose in strength, would it not, as regarding its power of resisting the internal pressure?—Assuming it to be made proportionately strong for the diameter for external pressure, I should think it would be made and remain proportionately strong for the internal pressure.

3383. If you proportion your thickness to the diameter?—Yes.

3384. Would not that very materially increase the cost?—Yes; but we always assume

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assume that in calculating the cost of a tunnel or sewer, that the thickness is increased in proportion to the diameter.

3385. What is your opinion as to the point on which there has been different evidence here; do you think such a tunnel as this may be put in with more or less danger in proportion as it is deep or shallow; deep from the surface of the ground; does depth render it more or less difficult to construct as far as accidents are concerned?—One must assume so many other conditions before giving an answer, that I am afraid it is not worth much. Assuming the soil to be exactly the same, and that soil to be moderately dry, I do not think the increased depth would have much effect one way or other.

3386. Mr. Brassey thought it would materially diminish the danger of injuring the foundations of the houses?—Yes; I think it would diminish the chance of injuring the foundations.

3387. Mr. Hawkesley had a different opinion?—That is, assuming that it is a tough material, free from water: now, if it should not be so, but should be material disposed to run with water, and having water in it, then the increased depth increases materially the difficulty and danger.

3388. You spoke of tunnelling under a town; you said you were in old coal measures; were they old worked-out coal measures?—No.

Sir *William Cubitt*, called in; and Examined by Mr. *Henderson*.

Sir *W. Cubitt*.

3389. I NEED hardly ask you if you are a Civil Engineer?—Yes.

3390. Have you directed your attention to the principle of the drainage of towns?—I have, occasionally.

3391. Were you one of the Metropolitan Commissioners of Sewers in October 1851?—I was appointed in October 1851.

3392. I believe you afterwards resigned that office?—After a time, I did.

3393. Are you now with Mr. Robert Stephenson, one of the Consulting Engineers of the Metropolitan Commissioners of Sewers?—We both resigned; and after our resignation the Commissioners applied to know whether we would accept the appointment of Consulting Engineers, and we did.

3394. Were you engaged with Mr. Walker and Mr. Brunel in reporting on the state of the city sewers in 1848?—I was.

3395. Have you considered the main features of this Bill, and examined the plans and sections?—Yes; I have seen the plans and sections. I have not gone minutely into its features at all. But two gentlemen made a report on it, partly at my request, Mr. Bazalgette, and Mr. Haywood, of the Metropolitan Sewers, and the City Sewers. I have seen their reports, and have conferred with them at the time they were making their report.

3396. Are you aware of the plans which Mr. Forster proposed for the south and north side of the Thames?—Yes, I just know them. I have seen Mr. Forster's plans, but I was in no way connected in getting them up, or in doing anything with them, because they were made before I was appointed a Commissioner, and the subject was not brought forward in earnest while I continued in the commission, but I know what the plans were.

3397. In your opinion, as an engineer, would the plan of the promoters of the Bill provide for the better drainage of the metropolis?—It does not provide for the drainage of the metropolis, properly so called, at all, that I am aware of.

3398. Does it do any more, supposing it successful, than prevent a certain portion of the sewage of the metropolis passing into the Thames?—Yes, it does that.

3399. Does it do more?—I do not know that it does; as regards its physical effect, I think not any more. I do not think it myself even necessary to do that, if proper means were taken to make the Thames as it ought to be, a proper receptacle and sewer to take away the filth of the metropolis and the surrounding districts. If the Thames were made, as it might be made, a much better outfall than it is now, for taking away the land waters, and with the land waters the sewage waters, if that were improved, as it might and ought to be, so as to have a deeper channel at all times, and no dry shores, and the water for culinary purposes, as is now being done, all taken from the Thames above the tide-way, in my opinion there would be no necessity for the public disturbing themselves about the Thames River. They would not make it altogether free from filth, do what they could; they could not make it half free; and therefore, if all necessity for

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taking away the remaining part of that filth was done away with, the expense need not be incurred. Moreover, London might be so drained, as it wants to be properly drained, by a means which will take the whole of the sewage down continually, and deliver it below low-water mark, at all tides and all times. It will then be no nuisance to the river or to the people. I do not believe anybody ever smelt the Thames. They have smelt the drying mud and the stench from 50 sewers opening into it with wide open mouths, as I have many a time; but the Thames itself I do not think need be at all a nuisance: I will show why, if I can.

3400. You spoke of the open mouths of the sewers; would you carry the sewage-water further out by pipes?—I would carry large sewer-pipes of cast-iron, and pipes that would bend to the shape of the bottom of the river, down close on the bottom, so as to take the shape of the bottom, so that their mouths should be at all times under low-water mark. Then if every main sewer was ventilated, as ought to be done, there would be enough draught of foul air going out at the top of the town in 500 places, more or less, according to circumstances, ventilated as the upcast shafts of coal-mines are, and the sewers would be sweet to go into, and kept ventilated by the fire. Then there would be a delivery of all the sewage into or below the surface of the Thames at all times, and the stench that now keeps coming up in our streets from the sewers would be completely done away with. Instead of the foul air coming out of the gratings, it would go into the gratings; that is a possibility also.

3401. *Committee.*] Did you recommend this mode of dealing with the sewage in your report of 1848?—No.

3402. Did you there propose to send the sewage down below low-water mark?—I do not recollect that.

3403. What was the object of that report?—A report on the state of the sewage of the city, to show the state of the sewers, to show what sewers they had, how much of the whole city was sewered properly, and how much remained to be done. There were 47 or 48 miles done, and about three or four miles wanted doing; and if they had been all laid out in parallel lines across the city, there would be one every few yards.

3404. In reporting on the sewage of the city, did you consider any mode by which the city could be relieved of the stench of those sewers not going down to low-water mark?—I do not think we had any complaints of the stench.

3405. In 1848 they could not find it out?—They had not at the time we had the instructions. Three of us made a report on the sewage, which was circulated at the time, and the whole of the remarks in that I can subscribe to.

3406. Mr. *Henderson.*] Were you not employed to show what the state of things was, rather than to report on what you thought they ought to be?—As they then were, what was the state of the sewers in London: that we did; and what was the best sort of sewers to put in, and sundry other things.

3407. Was there a doubt at that time as to the proper form or shape of sewers?—We reported on what we thought the best form of sewers, and that no sewer should be made in the public street that a man could not walk into, and clean out.

3408. This mode of carrying off the drainage into the centre of the river——?—I did not say the centre, but below low water everywhere.

3409. What effect would that have on the formation of mud-banks, or otherwise?—It would not affect the mud-banks at all; the pipes would be sure to go into the mud half diameter at least, perhaps a little more.

3410. Perhaps you can state whether the mud-banks have increased in size or number in the last three years?—I do not know that exactly; the water has got lower than it used to be; that I do know. There are several acres of mud-banks in Westminster alone.

3411. With respect to the lower portion of the land that skirts the south side, and some of the western portions of the north side, do you think it desirable to have the land waters taken off by means of a catch-water drain?—I think a great part of Bermondsey, and all that low neighbourhood, which is below high water, it is impossible to drain out entirely without help, so as to get it sweet and clean and healthy: it is not so now; but to do that, it would require the same draining that marsh lands require when they are embanked off, as I should embank this off by a land-water drain. Let the land water drain into a large drain, and run into the tide, so as to discharge itself into the tide; and that reservoir or drain should be

be so large that it would then be capable of being made use of to sluice out occasionally all the sewers at dead low-water mark on that side, which are about 25.

3412. The discharge in that case would be by gravitation?—The land-spring drain would be taken on a level line, falling a certain quantity of inches per mile, in order to take down at any time the greatest quantity of rain-fall, and take it down a little below the city into the tide-way. It might go into the top or the bottom of the tide-way; we will say the bottom, and then the catch-water drain would serve as a reservoir as often as it was necessary at a dead low tide to scour out the sewers with which we now have so much trouble in the lower parts of Bermondsey, and that low narrow district that requires to be drained, and never was drained.

3413. Would any pumping be required to be had recourse to?—I have stated so already. I have stated that the lower part should be served in the same way that we serve marshes, and be lifted up four or five feet. I should pump into a large cylinder, open at the bottom to the river, and at the bottom also of the pump. Therefore, as high as you pump the water, it would be equal to the height of the river, let it be what it might, and no higher; consequently, you waste no power. All these things should be done, and are required to be done, if means of sewering the metropolis in a proper manner were at hand; but we have never had enough. I had a great deal of trouble in getting some cast-iron pipes laid down in Bermondsey, in order to supply the tanners with their water: it arose out of a Chancery case. The Commissioners before that had put down earthen pipes, which were continually blowing up, and going down, or doing wrong at least. I got them to put down cast-iron pipes, and they have continued very well ever since.

3414. With regard to what you have said of the low level of the south side, or the west level of the north side, do you think any mischief would arise to the metropolis if all the sewage water was to go into the Thames?—I would have it all go into the Thames; and I should show the gentlemen who are so anxious to turn it into valuable manure, that there is a means of doing it out of the 50 sewers at a little distance back far better, and, in my opinion, much cheaper than they could work this great thing which they talk about, but will never do. I do not think they know exactly what they are about when they talk of doing that; I am sure they want experience. I mean to say, admitting that the sewers are all repaired in their proper place, as most of them are now which now exist, and were carried unbroken down into the Thames below low water, and with a shut back-door a little back into the town, so as not to go into the river, to have it worked or attended to at the back of that valve; to have premises erected on a larger or smaller scale, in order to take up all the sewage that was worth taking up, and then converting it into sewage manure; that, I think, would be the best way. They could not work so large a thing as they now propose; they could neither pump it out, nor manage it as they expect.

3415. Have you turned your attention to the plan which this company proposes, of tunnelling off the water, and pumping it for the sake of the sewage; physically or commercially, is it likely to succeed?—I think it is not at all likely to succeed, physically or commercially; but it might succeed if done in small masses on a smaller scale, and not having to pump it up at all, except from the sewer itself; and I am sure the parties would be of the same opinion themselves if they were to think a little while.

3416. What do you think of trying so vast an experiment as this on the metropolis?—I will argue against it all I can, because I am sure the parties would find themselves mistaken. All people who go in extremely large steps at one time must, I think, occasionally fail.

3417. Are you of opinion that an experiment should first be tried in a town of moderate dimensions?—A city from 100,000 to 200,000 inhabitants would be a good one to try it upon. A good means of improving the Thames might be laid down, I have no doubt; if combined with the improvement of the river, so much the better; if not, it still might be done. I would improve the Thames, so that there should be a regular regimen for it. It ought to be in such a shape in breadth and depth as to take the water off in all times. At the same time, I think, less than would make this great scheme would do it; the Thames would be improved, the sewage would be improved, and the whole town would go on very well. The money would be expended for a right purpose in both cases.

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Cross-examined by Mr. *Hope Scott.*

3418. The plan which you have just explained to the Committee was not included in your report of 1848?—We reported in 1848 whatever it might be.

3419. It did not include the scheme which you have been stating to the Committee?—No, not at all; we described the London drainage.

3420. When did this scheme occur to you?—The scheme has occurred to me scores of times. The drainage of large cities and towns I have thought of many times during a large portion of my life.

3421. Have you ever advised those to whom you are now engineer in the direction of such a scheme as that which you have now described?—Do you mean the Metropolitan Commissioners.

3422. Yes?—I have told them many times about things of that kind, and they as often told me they had got no money to do anything with.

3423. Have you ever told them that this was the proper mode of dealing with the sewage of London at the points of discharge?—I have told them of it; I do not know that I have reported it to them.

3424. Let me call your attention to the report of 1848, which bears the names of Mr. James Walker, Mr. William Cubitt, and Mr. Brunel: "The sewage of the city of London is discharged into the Thames by eleven outlets, of which the principal are, the London Bridge, the Walbrook, the Paul's Wharf, the Fleet, and the Irongate. The difficulty of collecting the contents of all these sewers into a great sewer on each side of and parallel to the river, and continued below London, would be very great now, owing to dock entrances, narrow streets and buildings, including the Tower"?—I think so now.

3425. "The enormous expense of the works, and the probable opposition to them, appear to render the practicability of such a measure very doubtful, to say the least; at the same time we consider the subject as deserving of serious consideration, and the object very desirable, if it can be accomplished; and the same observation applies to the proposal for entirely diverting the sewers' water from the Thames, for effecting which, we have as yet seen no practicable plan"?—I do not see anything there disagreeing much from anything I now say. I do not doubt that there are things that might have been improved, and might have been done better than we reported, if we had looked more a-head in speaking of the then state of the sewage. I am quite open to suggestions as to improvements at all times.

3426. I do not propose any suggestions, but merely a few questions by way of elucidation; supposing your sewer to be continued down to the low-water mark, during what period would the discharges take place uniformly?—As they now do exactly in point of time.

3427. What would become of the sewage-water when so discharged?—It would go into the mass of the River Thames; it would not go dribbling down its shores, and make such a stench as it now does on warm days, which is a great nuisance.

3428. When discharged into the mass of the River Thames, where would it be carried to?—It would be some millionth part of the River Thames, but would go away mixing with the River Thames.

3429. In whatever direction the River Thames was running at the moment?—Yes; whether up or down. All these things arose from the question called the Dolphin question, when people used to drink the water of the Thames. There was a place called the Dolphin (this was 20 or 30 years ago), which was used for pumping up the water for the purposes of the metropolis. The place was called the Dolphin, and that Dolphin was placed opposite to the mouth of the King's Scholars' Pond Sewer. It was not the purest and best place to put a suction-pipe in to pump water for the metropolis. There was a great noise made about it; a great many meetings, and great disturbance from that time to this, though the waters for the culinary purposes of the inhabitants of the whole of London are taken entirely away from the tideway of the Thames now—I am not sure of every one—but I think they are all now; bargains were made for it last year. There is nothing to disturb the taste of the inhabitants, or the smell of the inhabitants now, for the water is taken from Thames Ditton, above the reach of the tide.

3430. But you were referring to the period 25 years ago?—I am a bad hand at dates; it may be that.

3431. I lived near the Dolphin at that time myself?—I had some gentlemen come

come as a deputation to me, to ask me to devise some waterworks. One of the gentlemen asked me if I would let my servant bring him a glass of water; the man brought up a glass of water; this gentleman took the water, and looked at it, and tasted it, and he said, "This is something like water; if we could get water like this, I should be most happy." They came to consult me about water.

3432. Was that Dolphin water?—You will hear. "You like it, do you?" said I. "I think it is the brightest, clearest water I ever saw." I said, "That is taken up at the Dolphin;" and so it was.

3433. Would you have kept the Dolphin there?—No; but the water, if it was properly managed, and cleanly and nicely filtered, will come out very bright water; that is all I mean: I never approved of the Dolphin water.

3434. On the south side you have no doubt that there must be an intercepting low-water sewer?—I say so on the south side. I will explain what I want.

3435. I want to know what you did say?—The lands of a great part of that neighbourhood lie below high water, and a little above low water; but it will all run off at low water everywhere within a little; I believe quite everywhere at low water; but still the ditches and the pipes, and all the drainage concerns thereabouts, are so sluggish, that they never run off altogether; there is never time for it; and it is swamped with water, and then it will not run off, and causes a great deal of disease, especially during the time of the cholera. To get rid of that nuisance, I would do that at the least cost; I would embank it; I would put a land water-drain, and a large one too.

3436. Now for the sewage drain?—The sewage drain should be made to discharge into the Thames as low as it could discharge at all in a large sewer; that sewer should go down the river to a proper place, perhaps towards the Deptford Creek, and there join with one or more; but one is a case in point, and there join to a large upright pipe like a cylinder, open at the top, and closed at the bottom, and there should be a large pipe run out of that into the water of the Thames below low water, and there should be a pipe that the sewer should run into also; both pipes should run into that upright pipe; and on that pipe should be a very powerful pump to draw the water from the sewer, and pump it into that upright part, and that would run off by its own gravity into the Thames.

3437. You would not think of clarifying that?—No; what should you clarify it for?

3438. Would you think of extracting the valuable manure from the south side?—Yes; I should recommend that at every one of the 50 main sewers an establishment should be erected, by means of which, they would work more certainly, and more economically, and would get rid of all the rain-falls easier than by this large thing which they talk about doing. You quite mistake me if you think I have come here against saving the manure, and making it available.

3439. At the lower end of this south-side sewer, you would have your clarifying or depositing apparatus?—Yes; or at more places than one.

3440. On the north side you would have it at the discharge of each of the sewers?—Yes; that would be the most convenient, and there would be less interruption, and it would be less costly for premises, and the manipulation would go on so much easier. The parties cannot be aware of what these things are on a large scale; they cannot have experience in them, because they have not been done. They cannot have had experience in the making, or have an idea of the cost, or the difficulty that exists in working such an immense thing in the metropolis; they never can stop: if they stop, the whole thing is gone to wreck and ruin. If they let the the thing fail, there is an end of the benefit even to these parties, and it would very often fail.

3441. It is the great bulk of water that has to be dealt with that you apprehend would cause a difficulty?—The great bulk of the rain-fall would cause them great difficulty, because it would every now and then fill their pipes up entirely in a very little while.

3442. I am speaking now of the manipulation at the end?—The manipulation at the end would be in this intermitting difficulty, if the plan I have just hinted at, which every body must think about, if they think of the thing at all, if that could be at work at all times, and always be ready, and the rain-water was shut off into the sewer, go off at the first trap-door I mentioned, and through another long one, which I would have just inside the Thames, which would lift up with all extraordinary rain-fall. Three quarters of an inch of rain fell yesterday, and we saw nothing

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of it: in 12 hours there was nothing seen of it; it made no disturbance at all; but if the apparatus stated and explained in the evidence by the promoters of this measure had been there, they could not have carried off a third part of that rain-fall.

3443. Will it not depend on their pumping powers and the capacity of their tunnel?—They have stated the capacity of their tunnel, which is big enough to cost more than they would like, and would not carry off more than sewage, and not more than a quarter of an inch of rain water in 24 hours. But then the sewage comes in lumps, if I may say so; the whole of it comes almost in six hours.

3444. In London?—Yes.

3445. How is that ascertained?—If you ask some of these gentlemen, such as Mr. Haywood, they will tell you that it comes from a great quantity of water being used in the early part of the day.

3446. Do you mean to say that the difference of habits in different parts of the metropolis does not make great equalisation with respect to the discharge?—I think not. It think there must, at all events, be a great difference: the sewage runs very quickly through the sewers.

3447. Now, one word about the tunnel; it will be in London clay, will it not?—I cannot say that I know exactly, but I think it will, because I know London clay, and know what making tunnels in London clay is too.

3448. What sized tunnels have you made in London clay?—Thirty feet tunnels.

3449. Would it be difficult to make a tunnel of 8 or 10 feet at such a depth as is here proposed?—Making tunnels is not quite so easy a matter at any time, except they be made in hard chalk, which you could cut a tunnel through. You can do that for a short length, and build brick inside it. But taking London clay, it is about as bad a material as you can tunnel in, because that is very hard; but it is soft enough to squeeze, and when the superincumbent weight comes on it, as it must do at some 40 or 50 feet deep, I have known it squeeze bricks to pieces, the hardest that could be got, and a great deal thicker than this tunnel is.

3450. At 40 or 50 feet deep?—Yes; the London clay moves very slowly; it is nearly twice as heavy as water, if not quite, and the weight of it is excessively great when pressing hydraulically, and in all directions: it has the principle of fluidity in it, although it is so hard: it is a very difficult thing to work.

3451. Who was the contractor that made your tunnels of London clay?—Mr. Brassey made them for my son; he made a great many tunnels between Barnet and Hatfield.

3452. Now, as to the up-cast shafts?—Yes; that is more a scheme; knowing that it has done so well for other purposes in other places, I say, if there were a few shafts or tall chimneys, which, if not the handsomest objects, are not the ugliest; if in the highest part of each set of main sewers they were collected into, underneath a fire always kept burning in one of these up-cast shafts, there would be a constant strong draught upwards, which you could scarcely stand against: it would suck the whole of the air out of the sewers, and, instead of the stench coming out of the gratings, it would go into the gratings, which would be a great improvement. That is the kind of nuisance which should be done away with in al towns.

Examined by the *Committee.*

3453. Would it be very desirable that the Thames should be improved in its outfall?—I think it should be.

3454. Explain what you mean?—The first symptom that I ever saw of improvement in the Thames, was some few years ago, when a Blue Book, or some plans were remitted to me by the Board of Works—I do not know the date—with a request that I would report on a mode of improving the wharfing in the Thames: I thought it a most excellent thing, and took a good deal of pains to look into it. It was to carry the then intended quays of the Houses of Parliament straight on through Westminster Bridge downwards, and to take off a great portion of all that bare ground opposite Privy Gardens, so many acres of it where the boats now lie aground half of their time, and more perhaps; to carry it down through the Chain Bridge, where it is now, and through Waterloo Bridge, and quite down to nothing at Blackfriars Bridge. There was to be a right good solid wharf, with room for a quay, and a road on it, and then to make some docks inside the wall, all the Westminster portion of it, in order to improve the trade, and give

opportunities

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opportunities for still more trade in that part. I took this thing up, and examined it very much. I took both sides of the river into my view, and proposed that a wall should be built as quays, and roads for all purposes on both sides, at such distances apart that they would keep as uniform a current as possible, and such a breadth altogether as to be sure to make a depth of six feet, or thereabouts, at low water.

3455. The channel would do that of itself?—It would do the thing well. The Thames, from being broad about Westminster, and the bridges having a number of small arches, throws up a number of mounds at the bridges, which are dry at low water. In fact, the Thames thereabouts looks dry all over, and there is scarcely room for a boat drawing two feet of water in the channel. That is all very wrong. The river has no right to run so wide, and then gravel would not deposit there; but scour it away, and the river would be good. I proposed that should be done; and the docks, instead of being inefficient docks, as I found the plan, should be good docks, with double gates, capable of being occupied with barges always afloat, and for the barges to get out and in at all times of the tide, and then they would be capable of doing three times the business, for they are some of them aground now.

3456. Will such an embankment of the Thames as you are speaking of diminish the flow of the tide?—No; because there are some smaller sections a little further up, and I think the London Bridge section would still be the smallest, and that does not now stop the tide improperly; but it is very bad indeed above; from there up to Vauxhall Bridge is very bad: there is a great mass at the bottom; it wants to be set about on good plans, and in a proper manner. That would not cost a large sum of money, but that would very much facilitate the drainage, and very much improve the navigation of the river; and I should supply those docks with water from high up the river, so that they should have fresh water always coming in. I think my plan is somewhere now in the Blue Book, but I have never seen it since.

3457. When you say you have considered this general plan, and that it would not cost much, can you give any notion of what it would cost?—I cannot; speaking of things of that kind, saying they do not cost much, I do not think much of 300,000*l.* or 400,000*l.* My ideas always go to the nature of the thing. I should say 200,000*l.* would not be much; it would be little; it very much wants to be done, and it would be the finest thing in the metropolis; it would tend to health certainly, and it would keep the water from never leaving a dry bottom to the bed of the river. When the water is stirred about by the tide it is never a nuisance.

3458. You were for some time one of the Metropolitan Commissioners of Sewers?—Yes. I do not know how long; whether it was over a year I do not know; it was not a great while.

3459. It has been stated here that the sewers that have been constructed are of too large a size; do you consider that the sewers that are constructed for the city, or the sewers constructed by the Metropolitan Commissioners of Sewers, are too large?—I never knew one too large yet, because I begin with this, that every sewer under a main street or public carriage-way ought to be sufficiently large for a man to go in without any discomfort, to rake it out and repair it. They cannot be less than three feet high, even in small roads or streets, to enable him to do that; five feet, or five feet three, and three feet six wide, is a very good sewer. Then there is a shape shown in that book which always has a narrow bottom (let the sewer be as large as it may) where the water runs.

3460. Do you prefer that shaped sewer to the circular sewer?—Yes; I prefer it to the circular shape, because a circular of that diameter will take a great deal more labour. All you want of a sewer is to have a flat bottom of about nine or ten inches, made so that a man can step with his feet and work in comfort, which he cannot do in those circular sewers.

3461. As far as strength is concerned, you consider that sewer equally strong with a circular sewer for all purposes?—I should give this a little thicker in the sides, according to the nature of the soil where the arc work is flat. The thing ought to be done well enough to last centuries in a main sewer.

3462. You were for some time one of the Commissioners of Sewers; do you think the district now within the jurisdiction of the Metropolitan Commissioners of Sewers is within the right limits, or too large or too small for the purpose of the drainage of the metropolis?—Well, the metropolis, properly so called, is extending so much and so rapidly in almost every direction, that I think it is not too

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too large; I think there might be some difference. I never entered into this question in the commission, but I think it might be a question as to the quantity of rating, according to the quantity of rental on a certain quantity of ground; that is a desirable consideration. But my views were generally confined to engineering questions; they were very badly set up with engineering help as to staff; they were never good yet.

3463. Do you think, looking to the rapid increase of the metropolis, that the jurisdiction of the Metropolitan Commissioners of Sewers should be extended?—For laying on rates?

3464. For making sewers, and, of course, for levying rates?—They may all stand very well for making sewers where they now are. There are about 120 square miles of them altogether; but sewers are wanted very much indeed.

3465. You said you were a great advocate for rendering the sewage of the Thames profitable for agricultural purposes?—Yes.

3466. As you are a great advocate of it, have you considered the plan now proposed to this Committee for dealing with it?—The principle I believe to be very good; but I think that they could not manage a thing so large as this. I think they begin on too large a scale to live with either credit or profit; but I think that they might do the thing on such a scale as, if the thing can pay at all, it might be sure to pay. I am quite sure that they might deal with the sewage of this metropolis in a far more manageable way, and a far more profitable way, on a proper scale, than they could possibly do to grasp the whole in one idea.

3467. You would put this apparatus, which is proposed to be at Barking Creek by the company, you would put something of the kind at the mouths of the present sewers?—Yes, I would. If the sewage goes on, and is finished, there necessarily would be on the two sides of the Thames together about 50 sewers. Now, every one of those sewers, taking a fiftieth part more or less, a thirtieth, to a sixtieth or seventieth part of the sewage of the whole of the metropolis would be quite ample for parties to deal with. I do not say one party should deal with this; but a company like this might deal with as many of them as they could, and they would be able to do their work better, to do it at their own times, and it will not run wild, and it will never stop them, as it is sure to do in this scheme of theirs. And then the difficulty of being obliged to clear out their tunnel sometimes; that they cannot have thought of, but I have, a good many times; I should not know how to manage it; there would be a great deal of matter from the metropolis get into the tunnel, which neither their pumps nor any thing could touch, and it would tend to block it up very much. There are a great many difficulties attending the thing, which I am quite sure they cannot have thought of, and which they cannot have experience of; whereas, by having a reasonable quantity of sewage at a time to deal with, they might in a comparatively small building carry on all their operations without any nuisance to the neighbourhood at all, and get all the sewage that would be worth getting out of it without interfering with any one.

3468. You have so far confidence in the system that you think it would be a means of getting the manure without being in any way a nuisance to the neighbourhood?—Yes, I do think so, quite; I think I could do it so.

3469. Do you concur with the other witnesses who have been examined on the part of the Commissioners, that under any circumstances, it would be desirable to carry the existing sewers down to low-water mark?—I do not know how many of them agree with me, but that is my fixed opinion, for the reasons I have stated, and I hope they are all good reasons.

3470. Whether we are to have a system of intercepting sewers or not, still that ought to be done?—Yes. The intercepting sewers can be made at any time, if they are worth being made; but they ought not to be made at the cost and loss of time of the proper sewage.

3471. Have you considered what ought to be the size of those continuations; we will take the Fleet Ditch, for instance?—I know the Fleet Sewer; I have been up it.

3472. What ought to be the size of an iron cylinder for that; you contemplate an extension that is to carry the contents of the Fleet to low-water mark?—I thought I had explained that. I will begin with the Fleet, which is the largest of all. The Fleet takes a wonderful body of rain-flood down it; it is quite a torrent going down, and is sometimes 13 or 14 feet deep; I have known it that in the

the sewer itself. That would terminate in a large sewer quite big enough; an iron sewer, which I would have quite big enough to take the general rain-fall of this district. The inner sewer on this side of the Thames, on the land side, there would be short length of sewer, made of cast-iron, for strength and facility of putting in, and large self-acting opening gates, that should be large enough to take all the rain-fall coming from any part of the country. Outside that I should propose to have large cast-ironpipes—it may be three feet, perhaps, in diameter—which would take all the current going out of the sewage. If the rain-fall came, I propose to have a length of that pipe next to the shore, and next to the big pipe I have spoken of; and to take everything; there should be a door that should open on rough hinges, lifting up like a long flap, and pour out any sudden rain-fall, and then it would shut down again. It would be a tight sewer for all other things. The sewer would stretch itself out into a large mouth, by being done outside in the water of the Thames; but with a flap-door to stop off the tide, which would be come-at-able by men to do what they wanted to do with it. Next inside that door should be the apparatus for the sewage. That is a scheme that would work, because there is nothing unreasonable in it, or not capable of being done.

3473. Your system for improving the Thames by contracting it, would not endanger the overflowing of the banks at any part?—No; it would have this advantage; it would tend to make itself deeper than it is now, that is a great advantage; it should never be narrower than the openings of London Bridge all put together; that is another advantage. That is a most convincing proof, that if the whole now passes up and down freely through the London Bridge arches, the whole will pass up and down freely through a space a little wider above; that is a thing that does not appertain to the Commissioners of Sewers; but I have often thought that if one good steady plan should be laid down and acted on by the different Government Boards, it would be a great thing for this country.

3474. Do not you contemplate that there will be a determined resistance by the better class of property about Whitehall against having your docks brought up there?—They have coal-barges there now, and they would have clear water, and boats to move about, which would be a great advantage to them, and I think they would desire it.

3475. During the time that you were a member of the Commission of Sewers, did you press on your colleagues the necessity of carrying those pipes into the river?—No; I never presumed to press anything which could not be attended to.

3476. Was it simply from want of funds?—Yes; there is no difficulty in making a pipe to take the shape of the bottom of the river.

3477. The great desire was to get rid of the impurities from the Thames?—The public have talked a great deal, and have always done for the last 30 years, without knowing what they talked about, just as busy men set them about, and newspapers wrote to call the public attention to it.

3478. On the part of the City Commissioners there exists no want of means; their rate is now brought down to 2*d.*?—But you must take every square yard of property in the city, and see what it is worth.

3479. We are not investigating the cause of its being so?—They have a very rich cover to the soil.

3480. Have you ever recommended to the City Commissioners that they should carry out their sewers?—No, I have not. The report will speak for itself. Our instructions were to report on the then state of the London sewage. If the City Commissioners will ever honour me again to make them a general report, I will do it.

3481. Should you tell them that it was their duty to adopt that course?—I should advise them to do it.

3482. Mr. *Clerk.*] Their principal sewers do that already; the London Bridge Sewer and the Fleet Sewer?—Yes; but things running into the Thames, do not fit the bottom of the Thames, and therefore they do harm.

Mr.

14 June 1853.

Mr. *Henderson* stated, that he had no more evidence to offer on the part of the Metropolitan Commissioners.

Mr. *R. Gurney* being about to address the Committee on behalf of the City Commissioners,

The *Chairman* stated, that the Committee thought it unnecessary to have a second speech.

Mr. *H. Scott* replied on behalf of the Promoters.

The Counsel and parties were directed to withdraw.

After some time, the Counsel and parties were again called in, and informed that the Committee had decided that the Preamble was not proved.

[Adjourned to Monday next, at Twelve o'clock.

MINUTES OF EVIDENCE.

Great London Drainage Bill.

(1853.)

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